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THE CLASSIFICATION OF COAL

A Thesis Submitted by

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April, 1928.

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T H E C L A S S I F I C A T I O N O F C O A L

- by -

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A T H E S I S

Submitted to the University of Alberta in Partial
Fulfilment of the Requirements for the Degree of
Master of Science.



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P R E F A C E.

The investigation described in this thesis was carried out in conjunction with the duties of Fuel Analyst of the Scientific and Industrial Research Council of Alberta.

The writer wishes to specially acknowledge his indebtedness to Mr. Edgar Stansfield, Research Engineer in Fuels, for discussion and advice during the preparation of the thesis.

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T H E C L A S S I F I C A T I O N O F C O A L .

GENERAL INTRODUCTION.

The earliest reference to coal that has come down to us was by Theophrastus in "The Book of Stones", written about 200 B. C. He describes an earthy substance which would kindle, and which was used by smiths.

We have references to the use of coal in England during the Roman occupation, and coal cinders have been found among ruins dating from the same period. The Saxon Chronicle of the Abbey of Peterborough in 853 mentions coal, but no mention of it was made in the Domesday Book in 1085. Records preserved in Holyrood Palace show that coal was being mined on the shores of the Firth of Forth about 1200.

Coal mining as a recognized industry began after the signing of the Magna Carta in 1215. So rapidly did the industry expand that in 1269 coal was being shipped from Tynemouth. At the end of the century coal was being used in London, by the poorer people for heating, and by such artisans as: smiths, limeburners, and brewers, in their trade. However, with the exhaustion of sources of supplies of wood, came the introduction of new heating equipment, which made possible the use of coal as a fuel for heating castles and the houses of the well to do.

Even with such a limited field of requirement for coal, a use classification, probably based on the conditions of burning, would gradually be evolved. This rough use classification had to give way to a more definite system when new uses for coal were discovered, and as it became clear that all coal deposits did not yield coal equally suitable for all the requirements of the trade.

THE HISTORY OF THE

1700

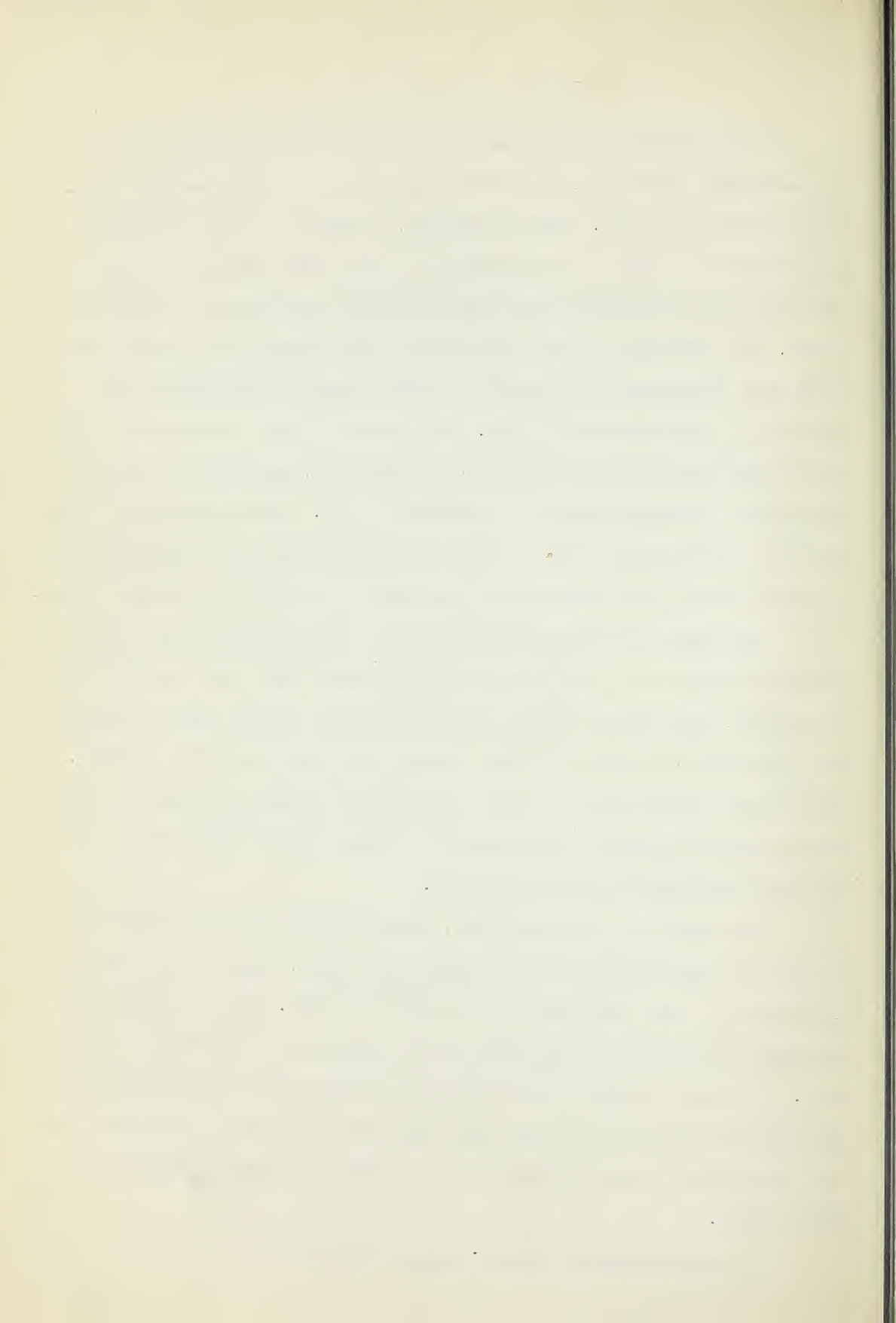
The history of the world is a vast and complex subject, encompassing the lives of countless individuals and the events that have shaped our planet. From the dawn of civilization to the present day, the human story is one of constant change and discovery. This book aims to provide a comprehensive overview of the world's history, from the earliest times to the modern era. It explores the major events, the lives of key figures, and the cultural and social developments that have defined our world. The history of the world is not just a collection of facts and dates, but a story of the human experience, of the struggles and triumphs that have shaped our lives. This book is a journey through time, a journey that will take you from the ancient world to the modern world, from the beginning of time to the end of time. It is a story of the human race, of the people who have lived and who are still living, and of the world that we have created. This book is a testament to the power of history, to the power of the written word, and to the power of the human spirit. It is a story that will inspire you, that will challenge you, and that will change you. It is a story that is as old as time, and as new as the day you read it.

The introduction of the bee-hive type of oven for the manufacture of coke in Germany about 1600, and of the by-product oven about a century later, opened new uses for coal. These inventions, followed in 1740 by the first successful use of coke in the manufacture of iron, made necessary a better system of classification of coals, since specific varieties of coal were required. The discovery in 1792 that coal gas could be used for lighting purposes made it necessary that criteria be established to distinguish coals suitable for the manufacture of gas. The invention of the steam engine, which in turn made possible the introduction of steamboats, and later of railway locomotives, caused new demands to be made for coal. These inventions and discoveries, all depending on coal either as a raw material or for the generation of power, led to, and made possible the Industrial Revolution in Great Britain.

Low temperature carbonization, (44) as a source primarily of a home supply of liquid fuel, but also yielding a smokeless solid fuel and important by-products, has received a great deal of attention, and has been the subject of a great deal of research in Great Britain and on the continent of Europe. The process of hydrogenation of coal (21 C) under pressure, invented by Professor Bergius in Germany, also aiming at a home source of liquid fuel, has also had much experimentation done on it.

The result of these inventions, making possible the production of a liquid fuel from low rank coals has given those coals, formerly considered of little value, a new importance in the industrial world. Even the large oil companies are looking to these coals as the future source of supply of liquid fuel. It seems, in spite of what has been said and written to the contrary, that the era of coal is far from being supplanted by the era of petroleum, but that coal aided by modern science is quite capable of competing with natural liquid fuels.

A standard system of classification, applicable to coals of all coun-



tries, is required in order to make the best use of the coal reserves of the world, and to estimate the amounts of those reserves available for the different uses.

The aim of this thesis will be to review the various systems of classification which have been proposed, and to investigate the adaptability of these systems to the coals found in Alberta. Consideration will be given chiefly to those systems of classification which are based on chemical criteria.

The following table shows the results of the survey conducted in the year 1960. The data is presented in a tabular form, with the first column representing the different categories of the survey, and the subsequent columns representing the numerical values for each category. The table is organized into two main sections, with the first section containing the results for the first part of the survey, and the second section containing the results for the second part. The data is presented in a clear and concise manner, allowing for easy comparison and analysis of the results.

CHAPTER I.

CRITERIA AND DATA FOR CLASSIFICATION OF COAL.

Requirements of a Classification System.

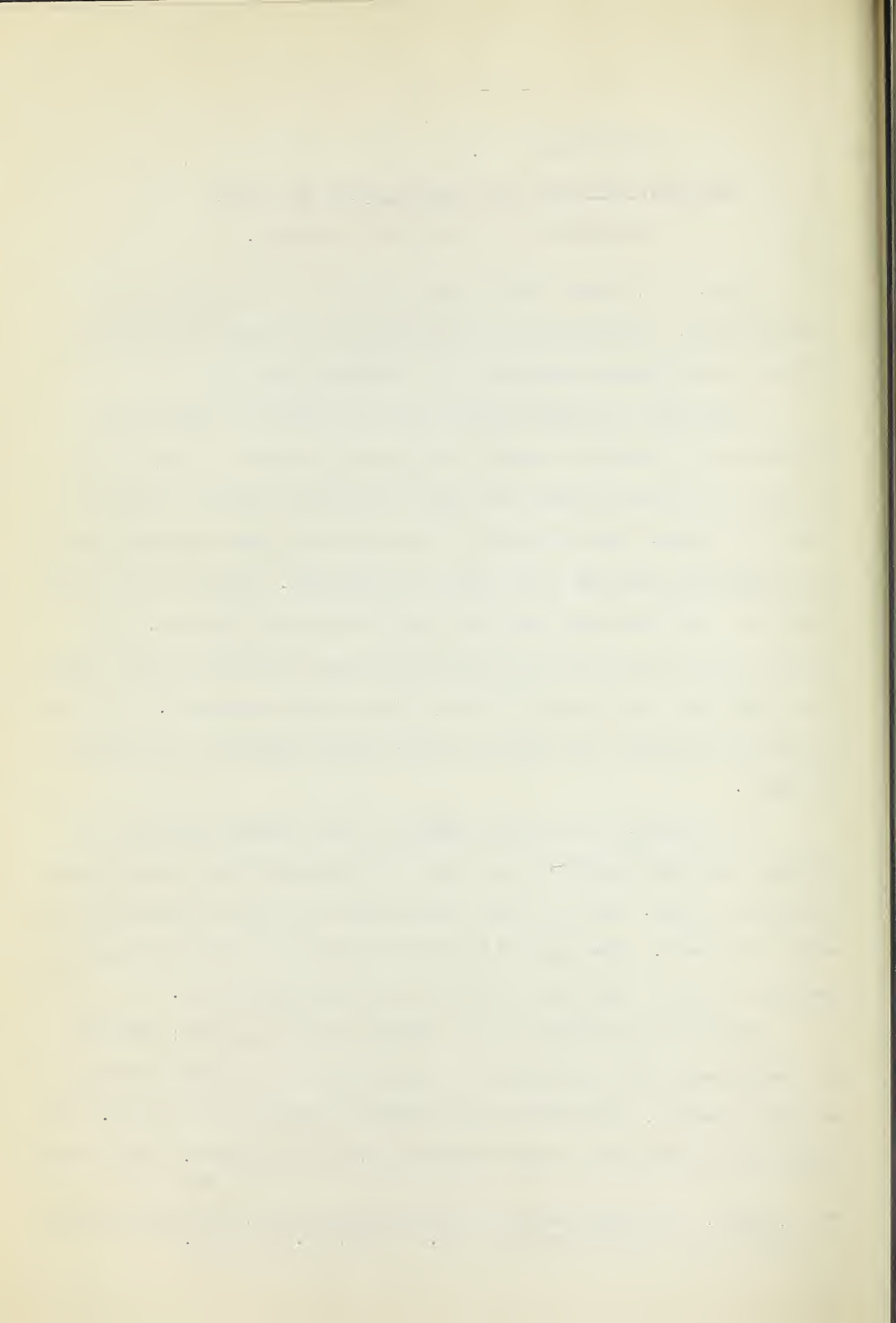
Prof. F. F. Grout* gives a good outline of the requirements of a classification. In discussing the classification of geological materials, he makes the statements contained in the following quotation:

"All bases (of classification) should be capable of quantitative determination, or exactly related to some property capable of such a test; so that, if no natural groups are found, an arbitrary line may be drawn to limit the classes. The best basis for classification should involve inherent and fundamental qualities of the materials considered. Allied to this is the requirement that advantage should be taken of any natural grouping. As a further help in selection, the basis or test should be easily applied, widely known, and have a wide range of values in the material classified. If no such classification exists, the choice of action depends entirely on the material concerned.

"In discussion of concrete examples of the criteria available, we find age generally discredited, and uses and geologic position producing many overlapping groups. There are left the physical and chemical properties and method of genesis. Some physical properties capable of quantitative measurement may be used if they also conform to the above requirements".

Referring particularly to coal classification, he states: "We are not dealing here with any grouping for special study of some minor problem, but with a general, comprehensive and scientific classification of coal. The groups must be selected to avoid overlapping as far as possible. Coals clearly

*F. F. Grout. The Classification of Geological Materials, and The Classification of Coal, Economic Geology, Vol. 4, 1909, pp. 646 & 652.



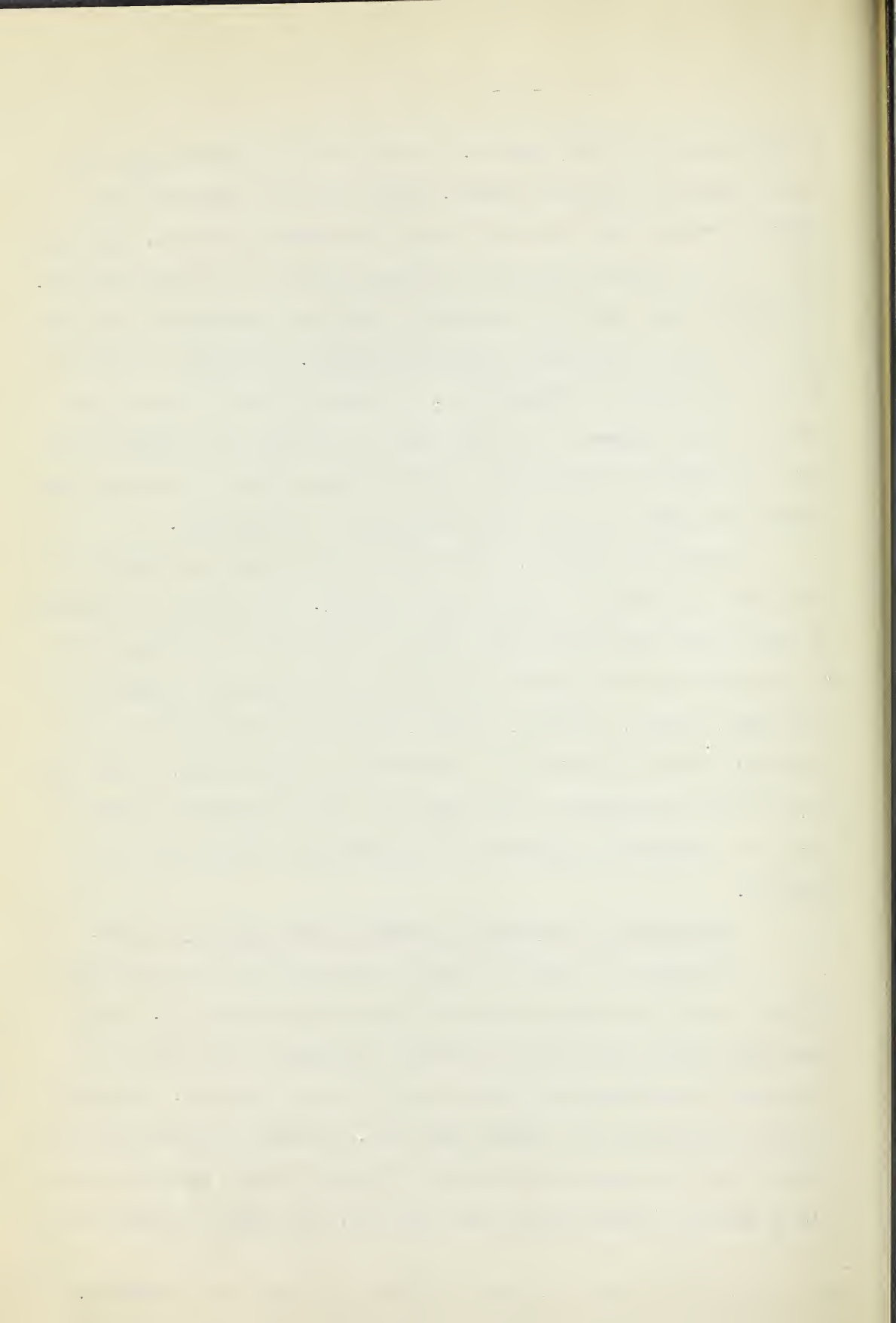
distinct must not be left together. We still know too little to make good use of genesis as a basis of classes. Aside from this, the physical and chemical properties of a coal are its most fundamental characters. The selection of the particular properties to use must be made on definite principles. The property must primarily be capable of quantitative expression. It should take advantage of any natural grouping that exists. It should, if possible, be easy and accurate of determination. In devising tests for quantitative determination of groups, those tests should be selected which disagree least with the commercial classification, and that method should be selected (other things being equal) which has the minimum number of exceptions".

As was to be expected, coal classification has been the subject of a great deal of attention during the last few years. It is generally recognized by those in any way connected with the coal trade that it is necessary (21 a) "to establish standard ranks* of coal which will be acceptable to operators of coal mines, dealers, consumers, chemists, engineers, and geologists; and to accurately define the limits and characteristics of these ranks, so that they may be readily recognized and differentiated, and to prevent the attempt to settle the question by committees and commissions not familiar with the subject".

Difficulties to be Overcome in Making a Classification of Coal.

The making of a system of classification which shall be applicable to coals of all types and ages presents a great many difficulties. Coals have been produced from different vegetable substances so that there is a divergence in constitution at the very start of their formation. Then there is great difference in age between some coals. Different original vegetation, coupled with differences in conditions of pressure and heat, makes it impossible to base any reliance on the age of the coal, as a basis of classification.

*The word "rank" is used to designate changes in coal due to metamorphosis.



The coals in Great Britain are of Carboniferous age. Most of those being mined in Eastern America are of the same age. Coals of Tertiary age are being mined on the continent of Europe. In Alberta there are three coal horizons (45), all of Cretaceous age, but representing a very great lapse of time between the laying down of the lower and upper horizons.

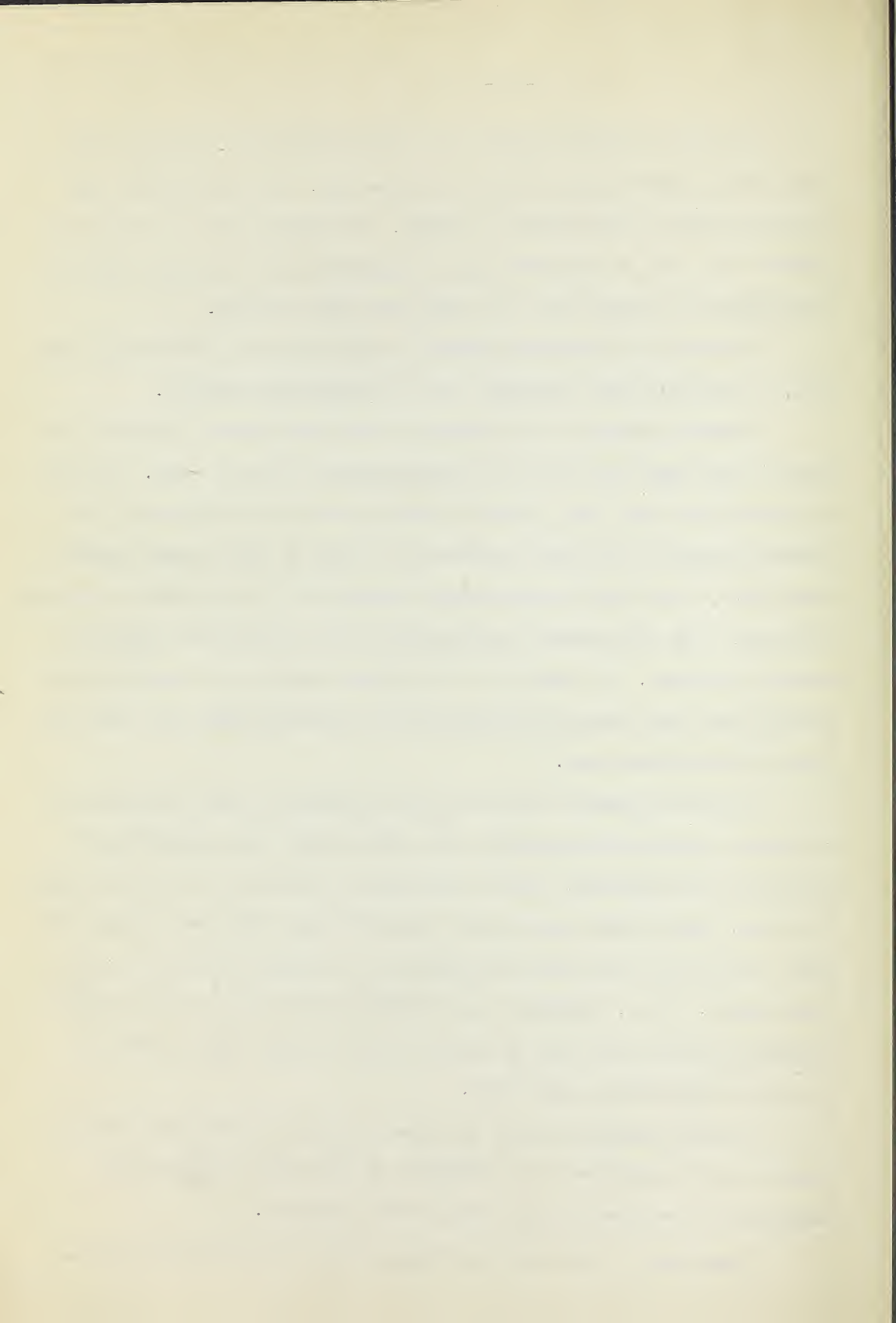
The three coal horizons referred to above occur in the Kootenay formation, in the Belly River formation, and in the Edmonton formation.

Pressure exerted in the upheaval of the Rocky Mountain Cordillera has played a very important part in the metamorphosis of Alberta coals. So great has this effect been, that, while bore holes show small variations in rank between successive coal seams encountered, in spite of time elapsed between depositions, a very appreciable increase in maturity is encountered in the same coal seam, a few miles nearer the Rocky Mountains, and therefore nearer the source of pressure. The result of this abnormal pressure has been that some Alberta coals have undergone metamorphosis to a greater degree than have some coals of Carboniferous age.

Different vegetable substances and differences in age and conditions of pressure and heat have produced coals which though very nearly isomeric, yet, as is to be expected, exhibit differences in physical and chemical characteristics. Most British and American classifications have been proposed for small areas, and to suit coals whose method of formation and maturity have been similar. It is, therefore, not surprising that many of those classifications do not suit the coals of Alberta, where a large range of ranks of coal is encountered in a small area.

A casual consideration of the above factors is sufficient to impress one with the difficulties to be surmounted in obtaining a standard coal classification applicable to the coals of all countries.

Committees to undertake the drawing up of a standard coal classifi-



cation were appointed at the International Conference on Bituminous Coal held at Pittsburg in November 1926. Since that time a committee has been appointed under the National Research Council of Canada to make a study of the subject, with the aim of drawing up a standard classification. It is hoped that it will be possible to adopt the same standard system in both countries.

In Europe the system proposed by C. A. Seyler has been quite generally adopted, and the fuel literature refers to classes of coal as distinguished by that system.

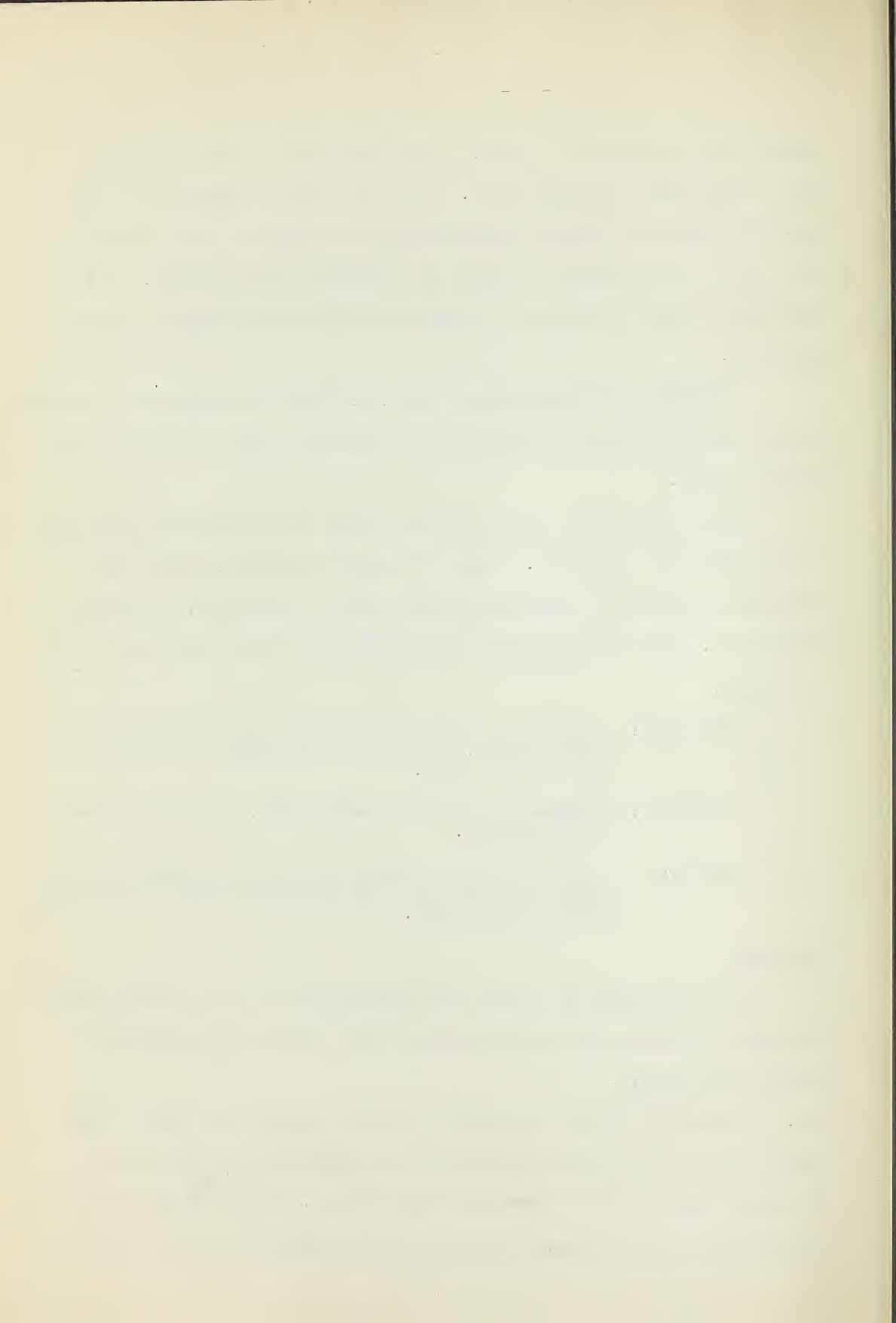
From the earliest days of the coal trade three distinctive varieties of coal have been recognized. Though variously designated, these three varieties correspond to those now broadly known as Anthracite, Bituminous, and Lignite. The distinguishing characteristics of these groups are roughly as follows:

- Anthracite: a hard coal, deep black in color, low moisture content, does not soil, ignites with difficulty, and burns without flame or smoke.
- Bituminous: generally burns with a smoky flame, and gives off much gas on heating.
- Lignite: retains a woody or earthy structure, is brown in color, slacks on weathering, and contains as much as 30 to 40% moisture when mined.

Data used.

For the purpose of testing the applicability of the different classifications to Alberta coals, use was made of the results of the following analyses and tests:

584. Proximate analyses and calorific value determinations made in the laboratories of the Scientific and Industrial Research Council of Alberta, on samples supplied by the Provincial Mines Branch. These samples represent fifteen mines in the Kootenay formation and one hundred and eleven townships



in the Belly River and Edmonton formations.

40. Ultimate analyses made in the laboratories of the Scientific and Industrial Research Council. The samples in this group were as follows; nineteen from the Kootenay formation, six from the Belly River formation, and fifteen from the Edmonton formation.

61. Ultimate analyses made in the Fuel Testing Laboratories of the Department of Mines at Ottawa*.

10. Ultimate analyses made in the Fuel Testing Laboratories of the Department of Mines at Ottawa*.

33. Ignition Temperature Determinations made in the laboratories of the Scientific and Industrial Research Council.

24. Determinations of the oxidizable constituents (Ulmins) of coal made in the laboratories of the Scientific & Industrial Research Council.

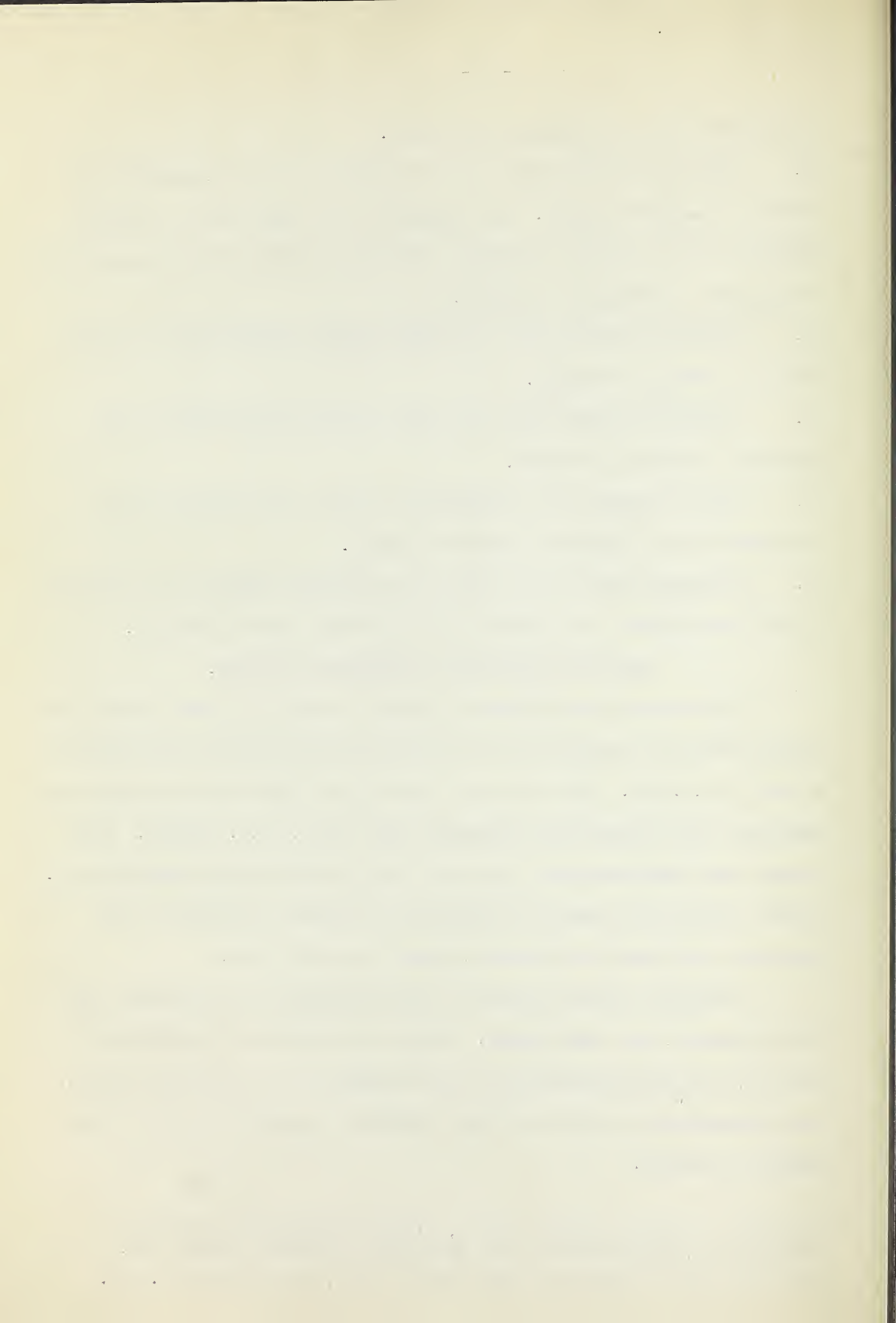
Methods of Carrying out Analyses and Tests.

The Scientific and Industrial Research Council in their laboratories adopted methods of analysis of coal which are substantially those laid down by the A.S.T.M.(4b). This means that results obtained there may be used in comparison with analyses made elsewhere under the A.S.T.M. methods. Some changes have been made where they would lead to more accurate determination. Briefly outlined the methods of Proximate and Ultimate analysis by the Scientific and Industrial Research Council are given below.

Proximate analysis consists of the determination of moisture, ash, volatile matter, and fixed carbon. These are not definite constituents of the coal, and the determinations depend on arbitrarily standardized tests. The determination of calorific value is usually considered as part of the proximate analysis.

* Analyses of Canadian Fuels, Part 4, Alberta & Northwest Territories, Bulletin 25, Mines Branch of the Department of Mines, Ottawa, 1922.

° Investigations of Fuels and Fuel Testing, 1925, Mines Branch No. 671.



The analyses are made on the air-dry coal. Air drying* is done by exposing crushed coal in shallow pans at room temperature for 48 hours, in a current of air of 60% humidity. This is not a method of the A.S.T.M. but has been adopted by the Fuel Testing Laboratories of the Mines Branch at Ottawa. The results obtained by this method are independent of the humidity conditions of the atmosphere at the time, and hence results so obtained are strictly comparable.

The total moisture in the original coal is calculated from the loss during air drying and the moisture retained by the coal after air drying. Moisture is the loss in weight sustained when the coal is dried one hour at 106-7° C in a current of dry natural gas.

Ash is the residue left when the coal is burned in a muffle furnace heated to a temperature of 700° C to 750° C.

Gross Volatile Matter is the loss in weight of coal heated at 950° C for seven minutes, in a platinum crucible with a close fitting lid. Net volatile is gross volatile less moisture. Coals retaining more than 8% moisture on air-drying require pre-heating for five minutes in the muffle furnace at 800° C, after which they are given the full heat for six minutes.

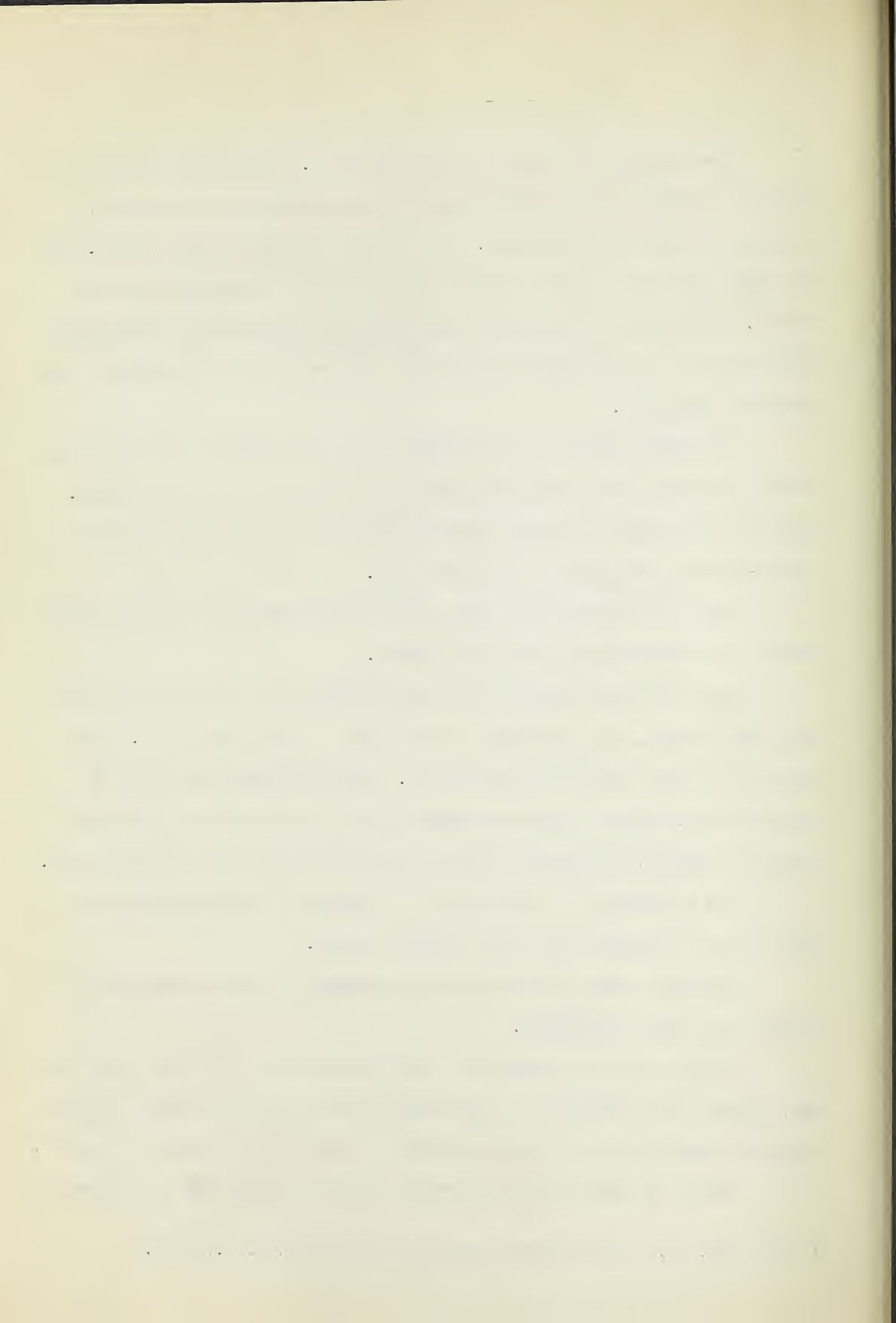
The percentage of fixed carbon is calculated by subtracting from 100 the sum of moisture, ash, and volatile matter.

Calorific value is determined by burning the coal in compressed oxygen, in a bomb calorimeter.

Ultimate analysis consists of the determination of carbon, hydrogen, ash, sulphur, and nitrogen, and the calculation of the percentage of oxygen by subtracting the sum of the percentages of the above constituents from 100.

Carbon and hydrogen are determined by burning the coal in a combustion

* Report No. 10. Fourth Annual Report of the S. & I. R. C., 1923.



turnace in a current of dry oxygen and absorbing and weighing the water and carbon dioxide so produced. The ash from the proximate analysis is used. Sulphur is determined by the Eshka method, and nitrogen by a modified Kjeldahl method.

Adjustment of Analyses.

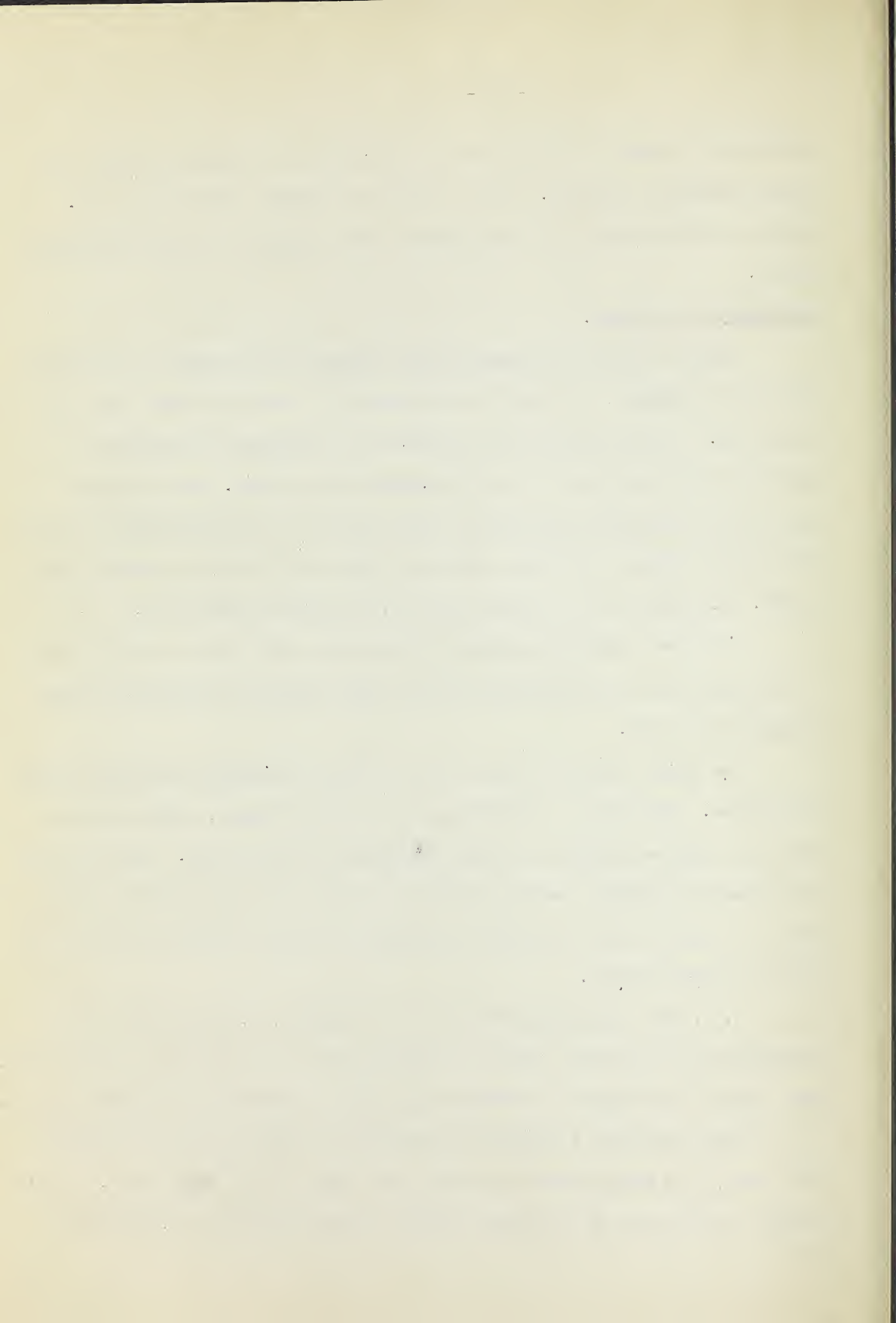
Before any use for classification purposes can be made of the results obtained by analysis, they must be calculated to a basis such that they are comparable. It has generally been customary to calculate the proximate analysis to the ash free, or ash and moisture free, basis. The ultimate analysis was generally calculated so that the sum of the percentages of carbon, hydrogen and oxygen, or carbon, hydrogen, oxygen and nitrogen, together made up 100. This might be on the dry, air dry, or moist as mined coal.

In these calculations there is an inherent error due to the fact that the ash percentage as determined does not truly represent the mineral matter present in the coal.

The mineral matter of the coal may contain carbonates, hydrated shales, and pyrites. On burning, carbonates give up carbon dioxide, shales give up water, and pyrites oxidize to sulphur dioxide and ferric oxide. On account of these chemical changes, the ash as weighed is less than the original mineral matter of the coal, and a factor is necessary to correct the determined ash to original mineral matter.

W. S. Parr (30) at the University of Illinois, E. Stansfield (37) at the University of Alberta, and R. V. Wheeler (41) at the University of Sheffield, have studied the subject of correcting the ash, as determined, to mineral matter.

Parr worked out a formula for correcting to what he called the "Unit" coal basis, this basis being what others have described as "pure coal". Parr's formula corrects the ash to mineral matter by using the factor 1.08 which he



round best suited to Illinois coals, and also corrects for sulphur, all of which he regards as being present as pyrites. Parr's formula is:

$$\text{Non-coal} = 1.08 \times \text{ash as weighed} + 21/40 \text{ sulphur.}$$

Mr. Stansfield suggested a method of determining the relation of mineral matter to ash. This method was worked out in the laboratories of the Scientific and Industrial Research Council* (Ref. Lewis' Thesis) and has been fully described by Mr. Stansfield, as well as in the thesis referred to above.

In this method a coal is separated into fractions of different ash content, by means of solutions of suitable specific gravity. The calorific value of these fractions is plotted against their ash content (both on the dry basis). A straight line relation is obtained. By extrapolation the theoretic percentage of ash when the calorific value becomes zero is obtained. This percentage is always less than 100. Dividing the percentage of ash at zero calorific value into 100, obviously gives the ratio of mineral matter to ash. Though the ratios found vary considerably, 1.1 appears to be near the average of values obtained.

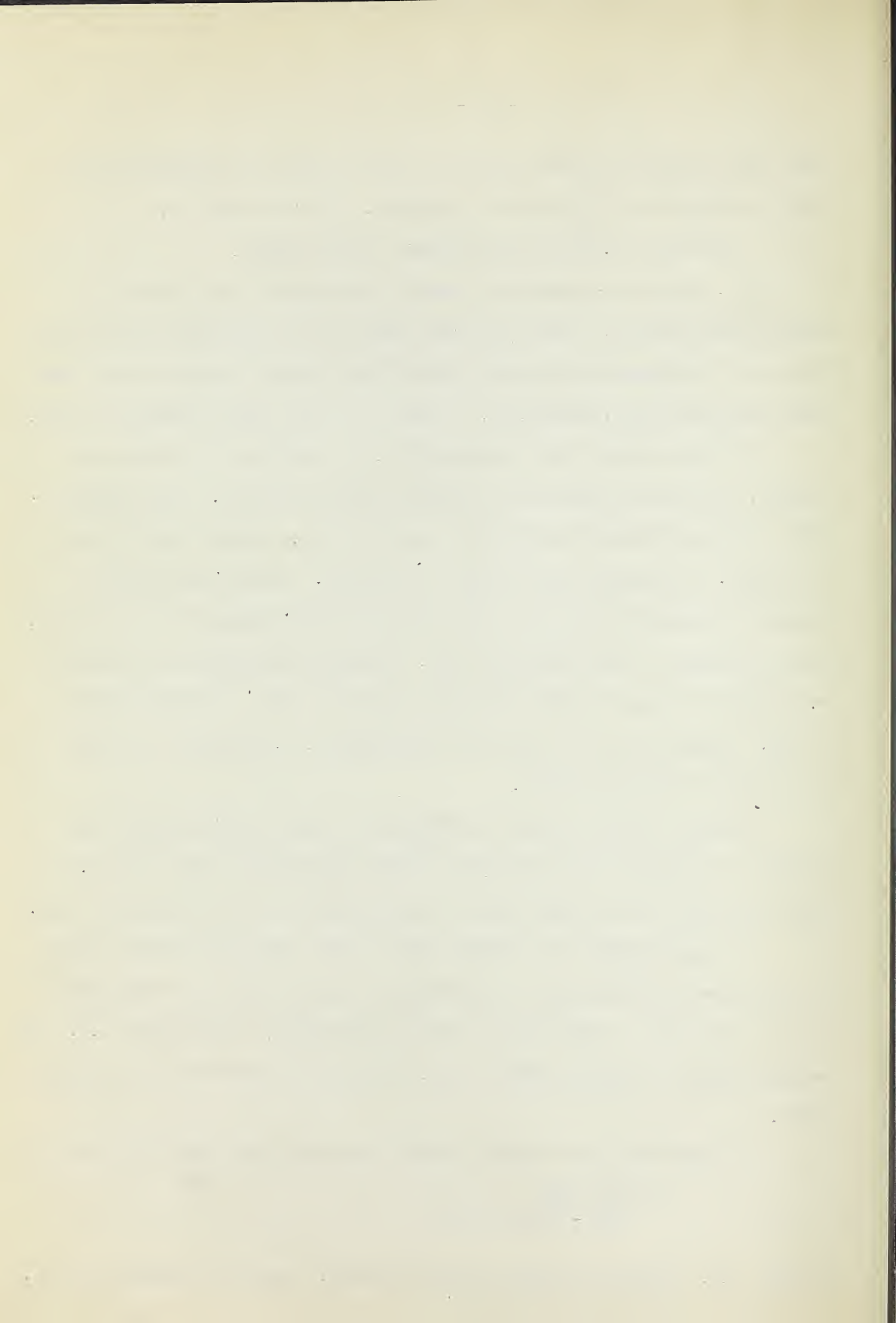
Wheeler, after a study of the subject, chiefly as it affected the carbon as determined in the ultimate analysis, decided that the factor 1.1 best represented the average ratio of mineral matter to ash for English coals.

In the adjustment of analyses used in this thesis the mineral matter is calculated by multiplying the percentage of ash by the factor determined for that coal, or, if that has not yet been determined, by the factor 1.1. The sulphur content of Alberta coals is low, so the correction due to it is negligible.

In correcting the calorific value to the pure coal basis the formula is:

$$H = \frac{H^1}{100 - (K \times A + M)} \times 100$$

* Lewis, J.W. "A Further Study of Alberta Coals". Thesis for Degree of M. Sc. University of Alberta.



where H represents the calorific value of pure coal; H^1 , the calorific value of the coal as analysed; K, the factor for converting ash to mineral matter; A, the ash as determined; and M, the moisture as determined.

In correcting volatile matter, it is assumed that the mineral matter lost in the ash determination is also volatilized in the determination of volatile matter, so the difference between mineral matter and ash (i.e. volatile mineral matter) must be subtracted from the percentage of volatile matter as determined to give the percentage volatile matter actually produced by the distillation of the coal. The volatile matter in the pure coal is determined by substituting volatile matter for calorific value in the formula given above. The percentage of fixed carbon in the pure coal is given by the formula: Fixed carbon in pure coal = 100-volatile matter in pure coal.

Mr. Stansfield (37), in his work, adjusted analyses for Alberta coals to an average ash of 10%, or mineral matter of 11% on the dry coal, instead of to the pure coal basis. He did this because a considerable error was involved in a high ash coal if the factor employed (1.1) did not quite suit the coal. The errors introduced in small adjustments from either side of the 10% ash are less likely to be serious.

These methods of adjustment give the correct calorific value, and only a small error, due to the absence of the oxidation effect, persists in the volatile matter.

In the adjustment of the ultimate analysis to the pure coal basis, a different situation from that encountered in adjusting the proximate analyses is met. The percentage of carbon, as determined, includes carbon from carbonates of mineral matter as well as that from the coal substance. The hydrogen determined includes hydrogen from water of hydration of mineral matter as well as the hydrogen of the coal. Sulphur, as determined, includes the sulphur present as sulphates in



the ash, and accounted for there already. (This is a very small error with the low sulphur coals of Alberta). The oxygen, as calculated, is made up of all the errors of the analysis, oxygen from carbonates and water of hydration of the mineral matter, as well as the oxygen of the coal substance.

Carbonates can be determined, and the carbon percentage corrected for, but no satisfactory method of correcting for water of hydration has been devised.

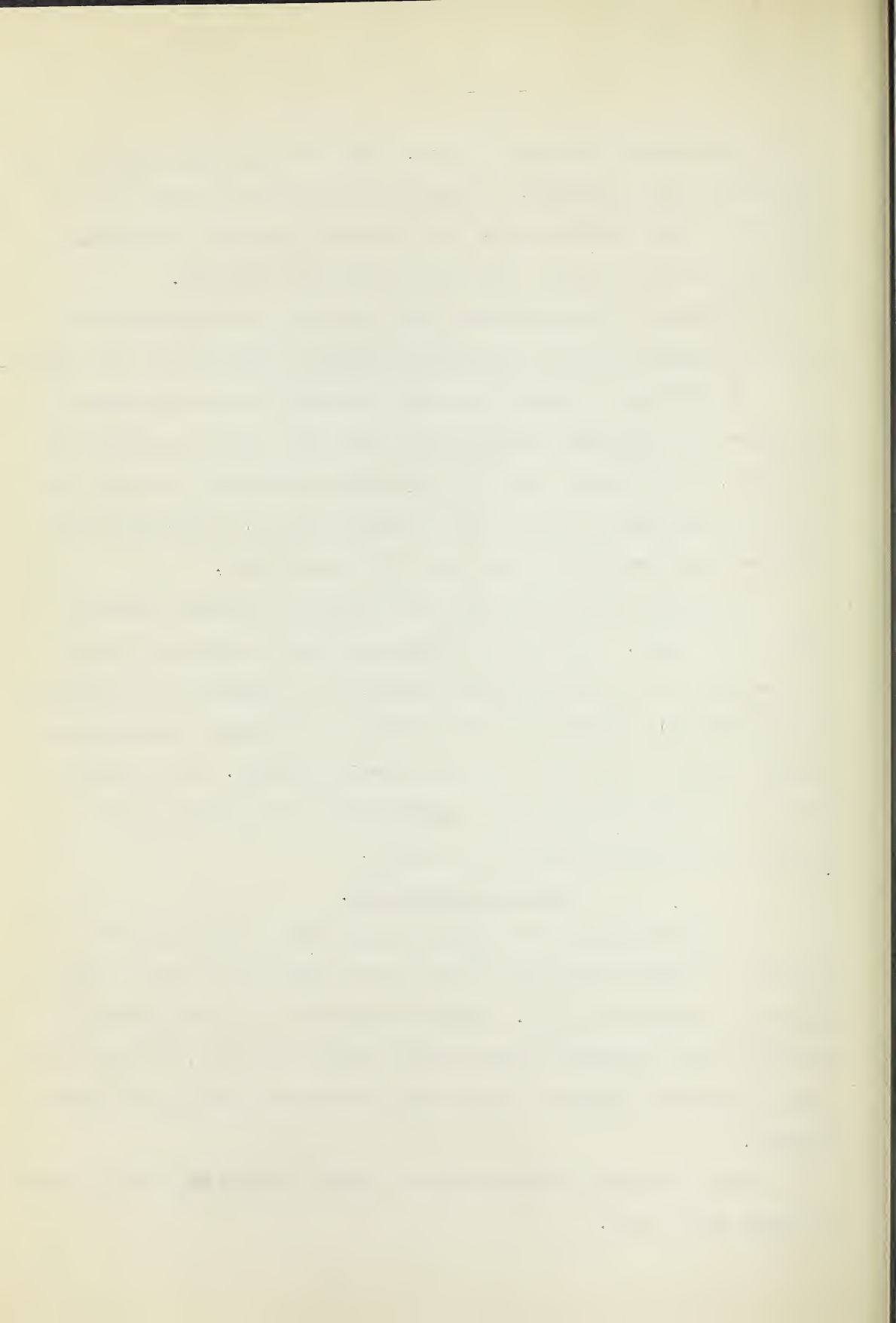
In adjusting to the pure coal using the mineral matter percentage, as calculated, the difference between mineral matter and ash is subtracted from the oxygen, as calculated, this makes the oxygen percentage so corrected too low by the percentage of oxygen from the hydrated shales. (The error due to oxidation of pyrites would be very small for Alberta coals).

The method outlined above has been followed in adjusting analyses used in this thesis. In view of the errors entering the adjustment it has been decided that in future, ultimate analyses in the Scientific and Industrial Research Council's laboratories will be made on coal cleaned by separating the original sample in a solution of suitable specific gravity. By this means a sample, low enough in ash content to eliminate most of the error due to mineral matter, will be obtained for analysis.

Ignition Temperatures.

The determination of the ignition temperature of coals was first undertaken by Wheeler and Burgess (47) in their work on the subject of the spontaneous combustion of coal. Ignition temperature of coal was defined by Wheeler as "the temperature at which under standard conditions, different coals begin to react with oxygen so rapidly that the ultimate appearance of flame is assured".

Parr carried out determinations of ignition temperature (48) on a number of United States coals.



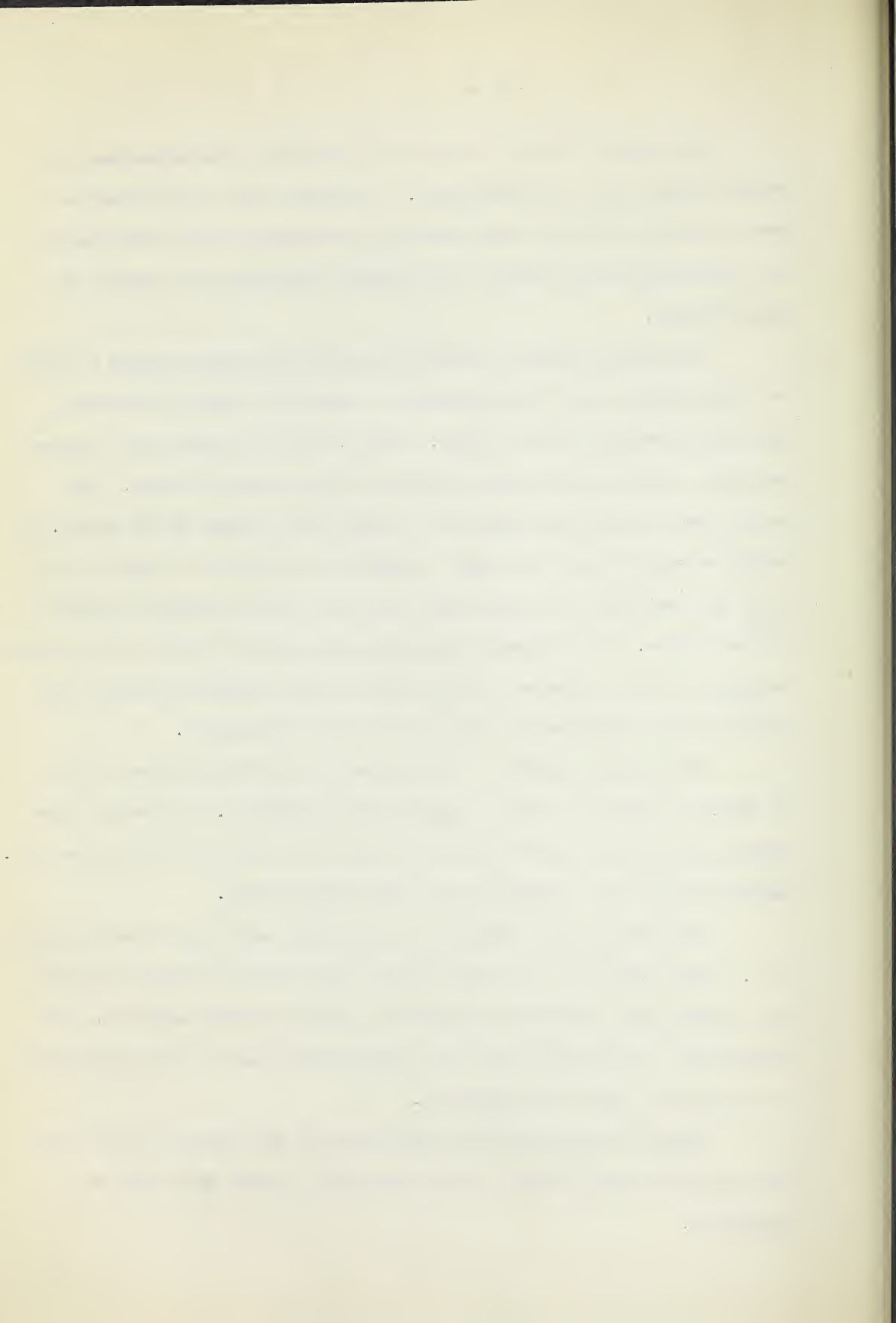
For results obtained to be at all comparable, the method and procedure followed must be standardized. A procedure was standardized for use in the laboratories of the Scientific and Industrial Research Council, and determinations were made of the ignition temperature of a number of Alberta coals.

The method employed consists in passing dry oxygen through a column of finely ground coal, the temperature of which is raised at a definite rate by an external source of heat. The coal used is ground with repeated screening, until it just passes a 200 mesh Tyler standard screen. The retort used is a $\frac{1}{2}$ " pyrex glass tube through which oxygen can be passed. A column of coal one inch in length is placed in the retort so that the coal is in the centre of the furnace when the retort tube is placed vertically in the furnace. One thermometer is placed with its bulb in the coal, another is placed in the furnace so that its bulb is just outside the retort tube, and on the same level as the bulb of the retort thermometer.

The current supplied to the furnace is controlled so that a rise of 10°C. per minute is shown by the furnace thermometer. At the same time Oxygen is forced through the column of coal in the retort at a definite rate. Readings of the two thermometers are taken every minute.

At first the coal temperature shows a lag behind the furnace temperature. When oxidation of the coal becomes rapid the coal temperature rises more rapidly than the furnace temperature, and eventually passes it. The temperature, at the moment when both thermometers show the same temperature, is taken as the ignition temperature.

Ignition temperatures were determined in the same way on the coals after they had been oxidised for six hours in a current of dry air at 106-107° C.



Ignition temperatures obtained on Alberta coals are shown in Table VI and the order of values obtained compared with the order the same coals are placed in by different classifications.

ULMIN CONTENT.

The determination of the oxidizable constituents of coal* is based upon the fact that low rank coals impart a deep brown color to a solution of potassium hydroxide, while as the rank increases the shade of brown gets lighter until, with anthracite, no brown color is given to the solution.

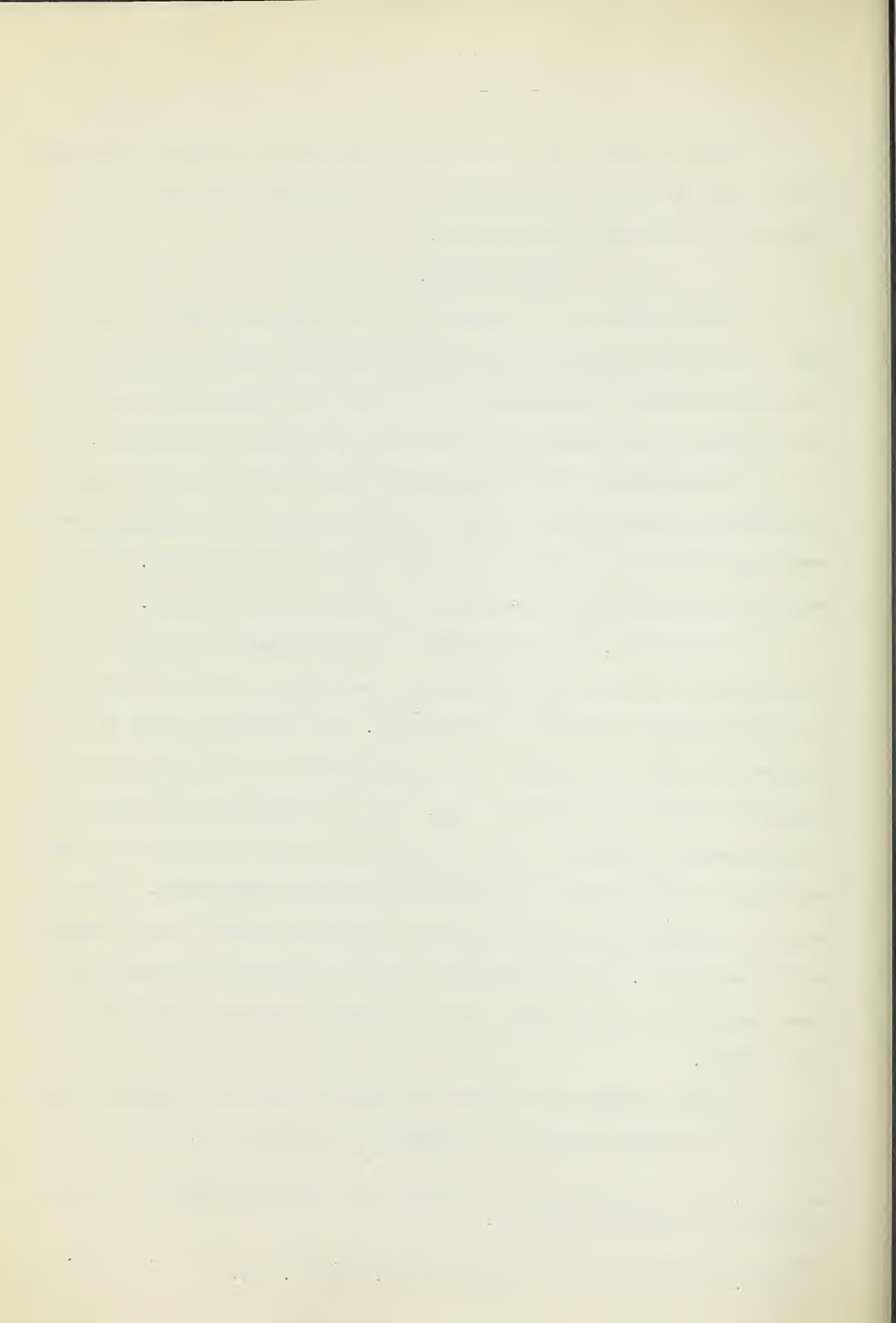
The development and standardization of the test from one requiring a colorimetric determination to one capable of quantitative measurement has been the subject of one part of the thesis recently presented by S. Zeavin, and requires no more than an outline of the method finally adopted.

In the method, now standardized, a weighed amount of coal, of known moisture and ash content, is digested for a set length of time in a potassium hydroxide solution of standard concentration. The solution produced is filtered off, and to an aliquot part of it is added standard potassium permanganate solution and phosphoric acid. This is boiled gently for one hour and the amount of oxygen absorbed by the coal determined by means of standard solutions of ferrous ammonium sulphate and potassium permanganate. This amount is expressed in grams of oxygen per kilogram of mineral matter-free and moisture-free coal. The purpose of the test is to distinguish between the lower rank of coals and to make possible a sharp division of those coals into classes.

Another attempt to make use of the ulmin content as a basis of classification of low rank coals was by Stadnikoff and Proskurnina**. Their aim was

*The part of the coal dissolved by digestion in potassium hydroxide solution is known as the ulmin compounds.

** Stadnikoff and Proskurnina, Brenstoff - Chem. July 1, 1926, pp.197-199. Abstr. Fuel in Science and Practice, Aug. 1926, p. 369.



to devise a quantitative test by means of which brown coals could be distinguished from coals of higher ranks. Their test was based on the amount of ferric hydroxide that a sample of the coal absorbs from a solution of ferric chloride. They assumed that this absorption depends on the amount of ulmins present in the coal, and claimed that their results on a number of coals justify this assumption.

Some work on this test was done in the laboratories of the Scientific and Industrial Research Council. The conclusion arrived at was that the phenomenon was one of adsorption, and as such was a function of the size of the particles of coal used.

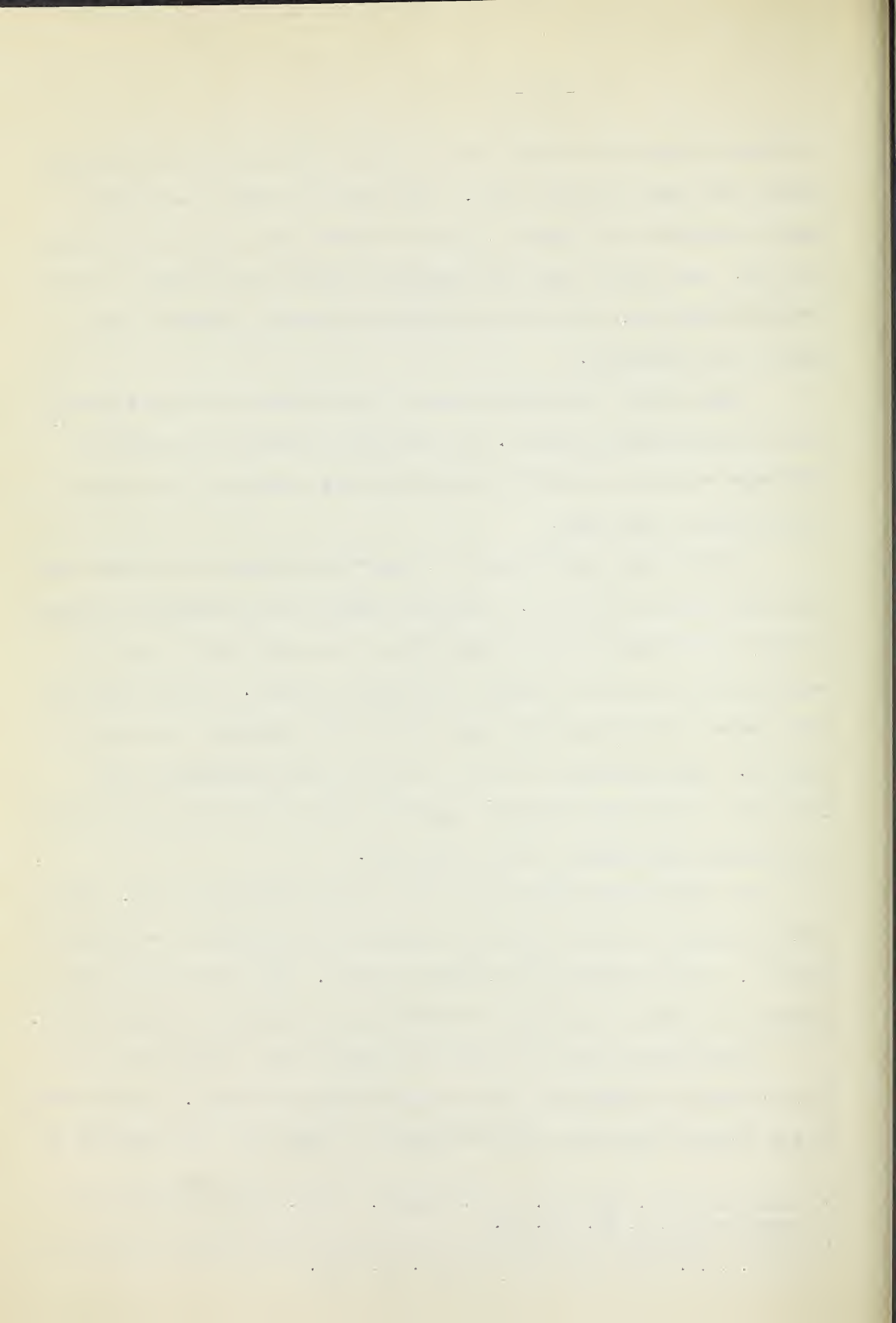
Another test, one devised by W. Fuchs* also depends on the humic acid and ulmin content of the coal. The method employed was to measure the amount of acetic acid liberated by the humic acids of the coal when the coal is shaken up with solutions of sodium and potassium acetate. It was found that brown coals contain about 80% of humic acid, while bituminous coals had only about 5%. Some experimental work will be done in the laboratory of the Scientific and Industrial Research Council to find if this test can be adapted for distinguishing between the low rank coals.

W. Francis^o has described work done on the oxidation of coal. He has extracted parts of certain coals with pyridine and chloroform in an inert atmosphere. He has oxidized the residues at 150° C. As a result of his experiments he advocates the use of oxidizability as a basis for classification.

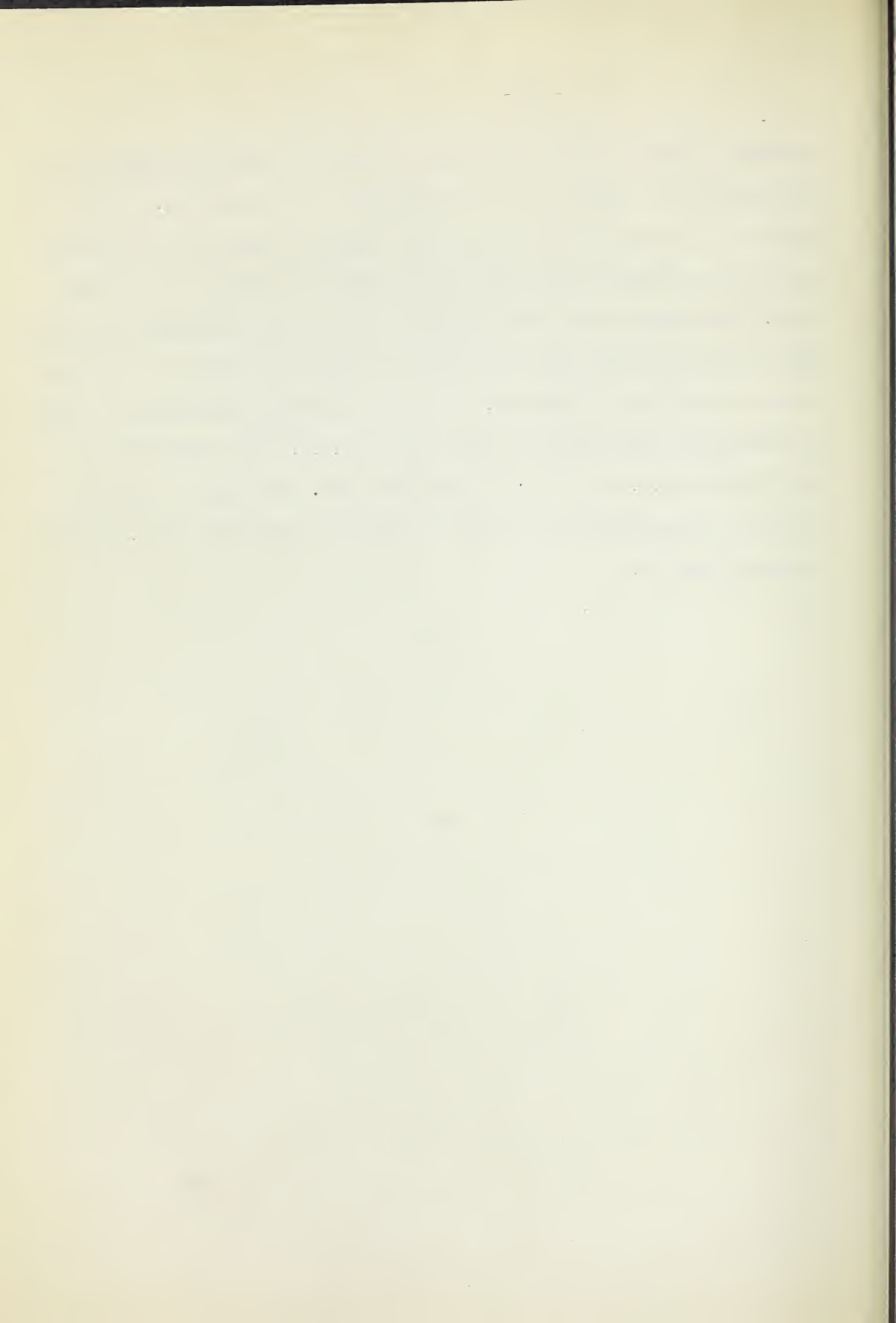
Some oxidation work of a different kind has been carried out in the laboratories of the Scientific and Industrial Research Council. In the drawing of the calorific value ash curves referred to on page 11, if the curve be

* Brennstoff-Chem. 1927, No. 8, pp. 337-340. Abstr. Fuel in Science and Practice, Vol. 7, No. 2 p. 95.

^o A paper presented at the meeting of the Coal and Coal Products Committee of the A.I.M.E. held in New York, on Feb. 23, 1928.



extended to meet the line of zero ash, the point at which the lines meet may be considered to represent the calorific value of the pure coal. A similar curve for the same coal after it has been exposed to oxidation by a current of dry air at 100-7° C invariably falls below that obtained for the fresh coal. The amount by which the calorific value of the pure oxidized coal falls below that of the pure fresh coal might be taken as an index of the susceptibility of the coal to oxidation. The loss in heating value produced by the oxidation has been observed to range from 50 B.T.U. for a semi-bituminous coal to 510 B.T.U. for a coal of much lower rank. The loss in calorific value so obtained does not seem to be capable of correlation with any other chemical property.



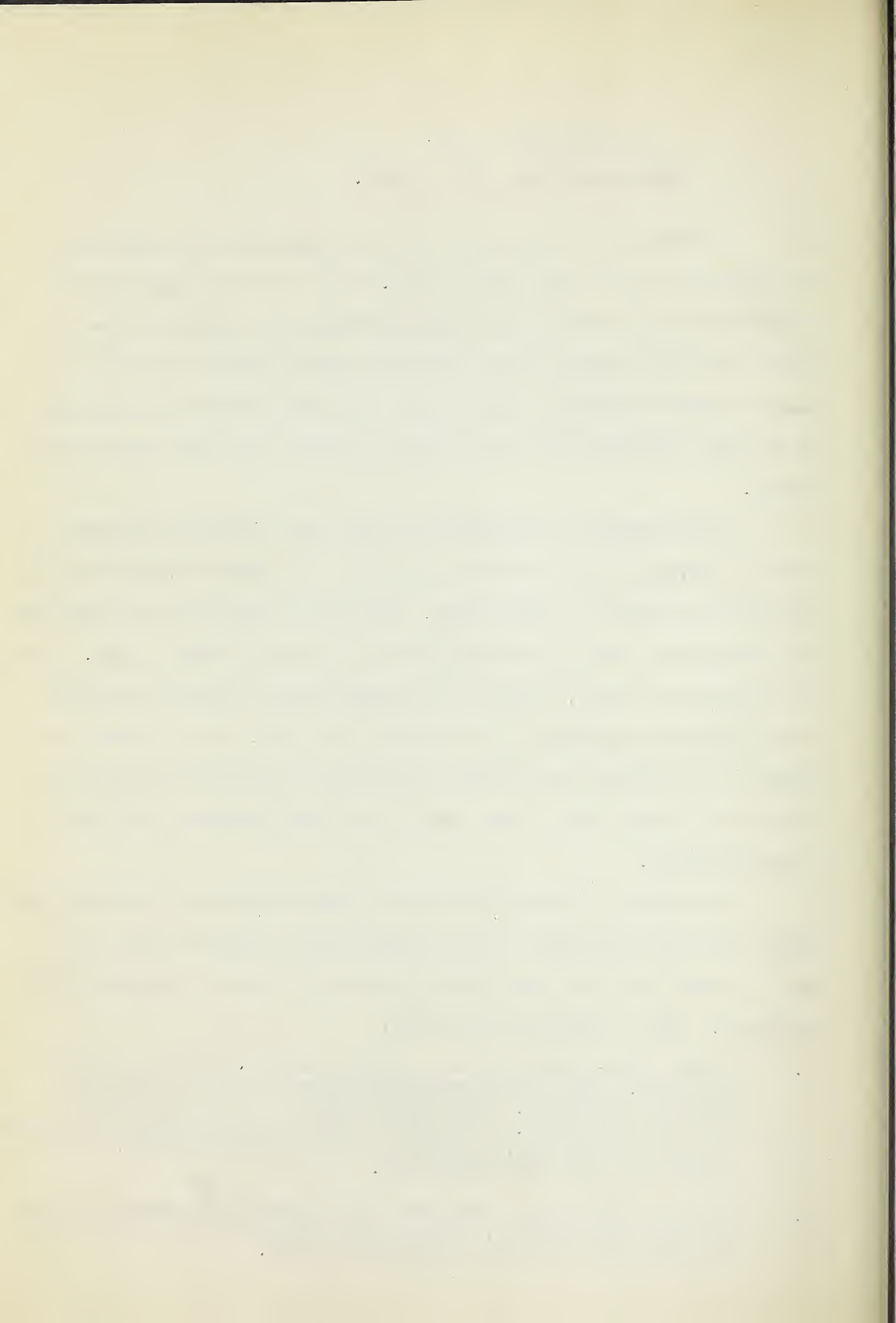
C H A P T E R I I.
C L A S S I F I C A T I O N S O F C O A L.

A division into classes such as that on page 7 is very indefinite, too indefinite to be of any practical use. One of the chief purposes of a classification is to provide some means by which it is possible to draw fairly sharp and distinct lines between the various groups, and by such means to make it possible to more or less definitely foretell the properties of the coal considered, and also the uses to which it can most satisfactorily be put.

A large number of classifications have been proposed at different times, all having in view the division of coals into definite classes and the assignment of limits to these classes. The earlier classifications were based on some physical property or properties of the different ranks of coal. Aiming at greater definiteness, workers on the subject began to give consideration to the chemical properties and constituents of the coal, so that nearly every factor of the proximate and ultimate constitution, as well as different combinations of these, have at some time or other been proposed as the basis of a classification.

The system of classification used in Great Britain and the United States about 1845 (Ure's Dictionary of Arts, Manufactures, and Mines (1845), page 969), divided coals into four classes chiefly on the basis of physical characteristics. These classes were as follows:

1. Cubical Coal: black, shining, compact, moderately hard, and easily frangible. Comes out in rectangular masses of which the smallest portions are cubical. The lamellae parallel to the bed plane on which the coal rests. Two varieties are (1) open burning, and is known as rough or clod coal, or cheery coal from its cheery blaze, and (2) caking, which is true smith's coal.
2. Slate or Splint Coal: dull black, very compact, much harder and less frangible than the last, resists cross fracture, burns without caking, with much smoke and flame, leaves white ashes.



3. Cannel Coal; between velvet and grayish black in color, lustre resinous, fracture, even to small fragments, trapezoidal, hard as splint coal, kindles readily, burns with a bright flame.
4. Glance Coal; iron black, occasionally iridescent, lustre shining, does not soil, easily frangible, has flat conchoidal fracture, burns without flame or smell except when sulphurous, produces no soot, seems to be coal deprived of volatile matter and bitumen and converted into coke from subterranean calcination.

Another classification (Watt's Dictionary of Chemistry, Vol. 1, p. 1032) of about the same time recognizes and names the classes as lignite, bituminous, and anthracite.

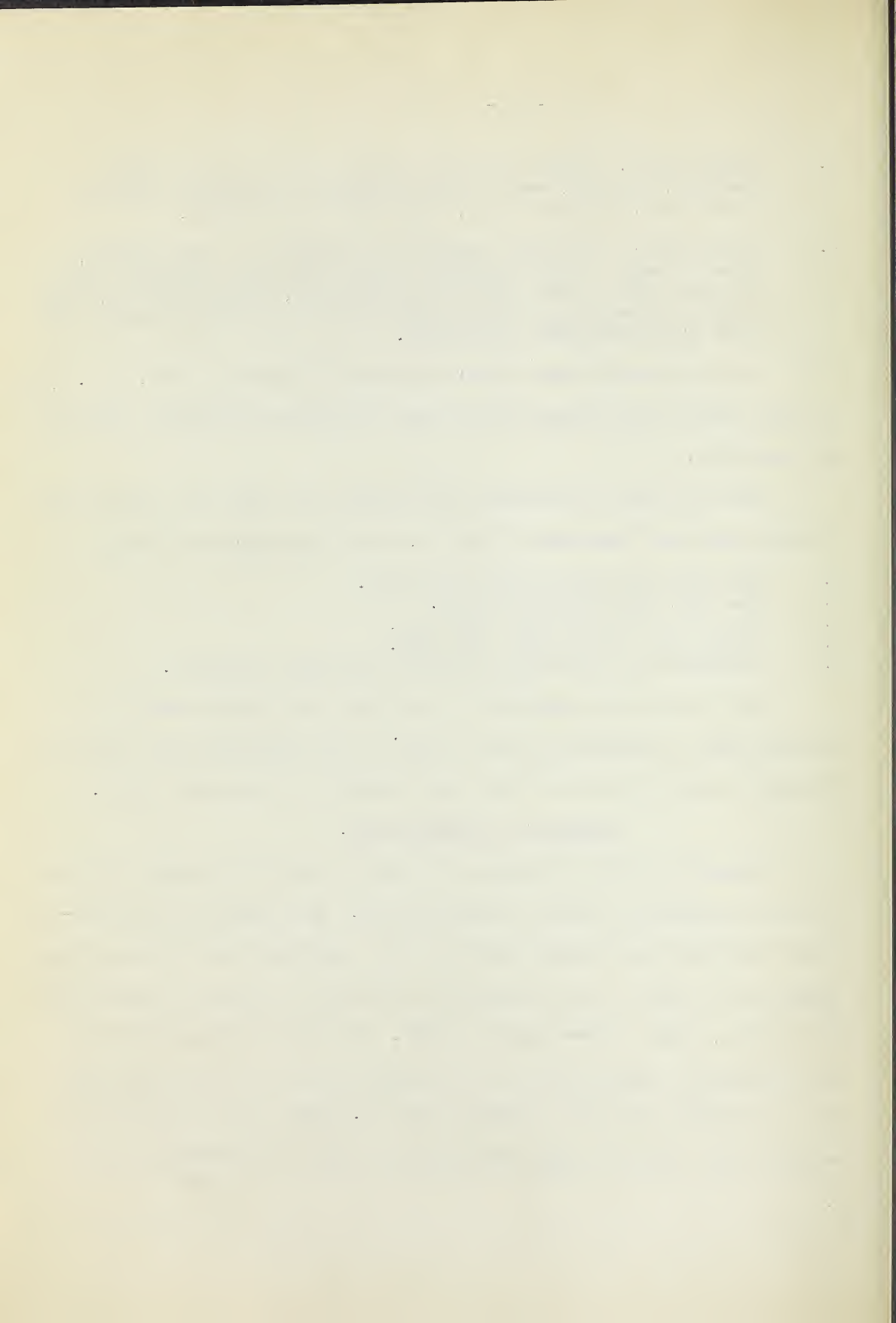
An early French arrangement (25) divided coals into five classes based on coking power and conditions of burning. The classes were as follows:

1. Poor coal, with long flame, non-coking.
2. Gas coal, long flame, poor coke.
3. Rich coal, shorter flame, fair coke.
4. Caking coal, short flame, best coke.
5. Anthracite and steam coal, little or no flame, non-coking.

No very definite separation of coals into the various classes was possible under a classification such as any of those outlined above, since the different classes as there outlined would overlap to a very great extent.

Regnault's Classification.

Regnault, in 1837, introduced the idea of using the ultimate analysis of coal substances as a basis of classification. As a result of very painstaking experiments and analyses he came to the conclusion that "the elementary composition of coals of the Carboniferous formation, for coals of one and the same quality, varies between narrow limits". He based his classification on the percentage of oxygen plus that of nitrogen in the ash and moisture free coal, and divided the coals considered into five groups, each of which had as an average the amount of oxygen plus nitrogen shown in the following table:



		<u>Mean Oxygen + Nitrogen</u>
1.	Anthracite	2.62%
2.	Lean, or short flame bituminous	4.47
3.	Bituminous or smith's coal	5.74
4.	Long flame bituminous	8.89
5.	Dry long flame	16.39

The names given to some of these classes might well have been retained, instead of being displaced by other designations less suggestive of the nature of the coal.

Fleck's Classification.

Fleck* in 1865, attempted a classification based on what he called disposable, available, or "free" hydrogen. By this term he meant the percentage of hydrogen in excess of that required to combine with the oxygen of the coal (i.e. hydrogen - oxygen / 8), thus making use of the rather debatable assumption that all the oxygen in the coal is in combination with hydrogen. He also introduced the idea of caking power. He used a graphic method of plotting disposable hydrogen against combined hydrogen, both as percentages of total carbon. His classification recognizes the following classes: (oxygen percentage being given instead of combined hydrogen)

Oxygen under 16% of carbon;

Disposable hydrogen under 4% of carbon - (Dry) sinter coals and anthracite.

Disposable hydrogen over 4% of carbon - caking coals.

Oxygen over 16% of carbon;

Disposable hydrogen over 4% of carbon - difficultly caking gas coals.

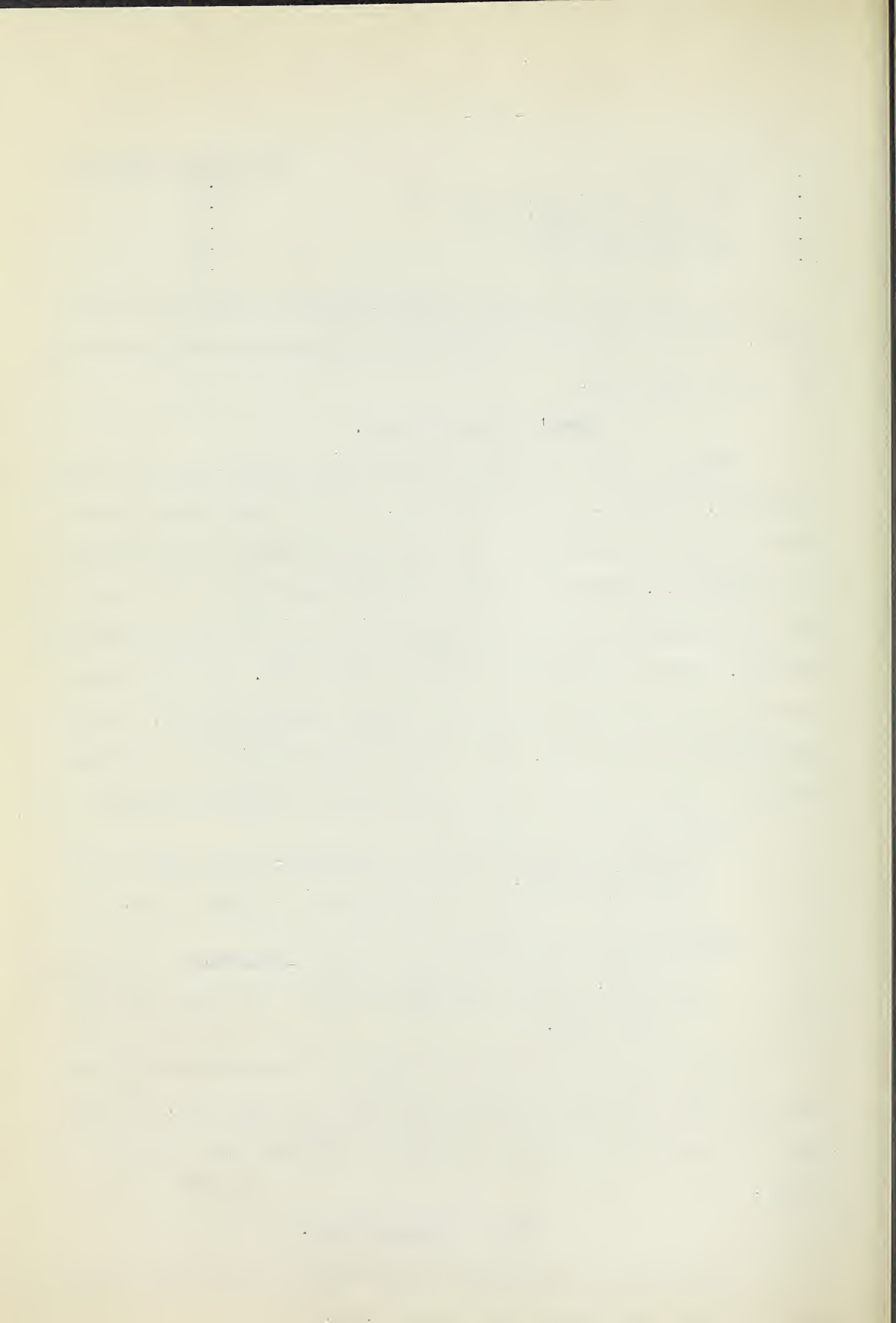
Disposable hydrogen under 4% of carbon - non-caking gas and sand coals.

This classification appreciates the fact that non-caking coals are found both when the oxygen is low and also when it is very high. The property of coking is attributed to an available hydrogen higher than 4% of the carbon.

Hilt's Classification.

In 1873 Hilt (23) introduced a classification based on the amount of

* Fuel in Science and Practice, Vol 3 (1924) p. 20.



volatile matter as a percentage of the amount of coke. He outlined the following classes:

1.	Lean antaracite	5 to 10	volatile per 100 coke		
2.	Sinter coals poor in gas	10 to 15.5	"	"	
3.	Caking coals	15.5 to 33.3	"	"	
4.	Caking gas coals	33.3 to 40.0	"	"	
5.	Gaseous sinter coals	40.0 to 44.4	"	"	
6.	Gaseous sand coals	44.4 to 48.0	"	"	

Schondorff's Classification.

Schondorff (23) based a classification on the appearance of the coke produced in a platinum crucible in the ordinary volatile matter determination. He considered that no correlation existed between volatile matter and coking power, especially when comparing different coal fields. His classes for bituminous coals were as follows:

Coke rough,	(Loose	1. Sand coal.
fine, sandy	(Molten hard, loose in centre	2. Molten sand coal.
and black.	(Molten hard all over	3. Sinter coal.
Coke gray and solid opening like a bud		4. Baked sinter coal.
Coke smooth and metallic, and strong		5. Baking coal.

Muck's Classification.

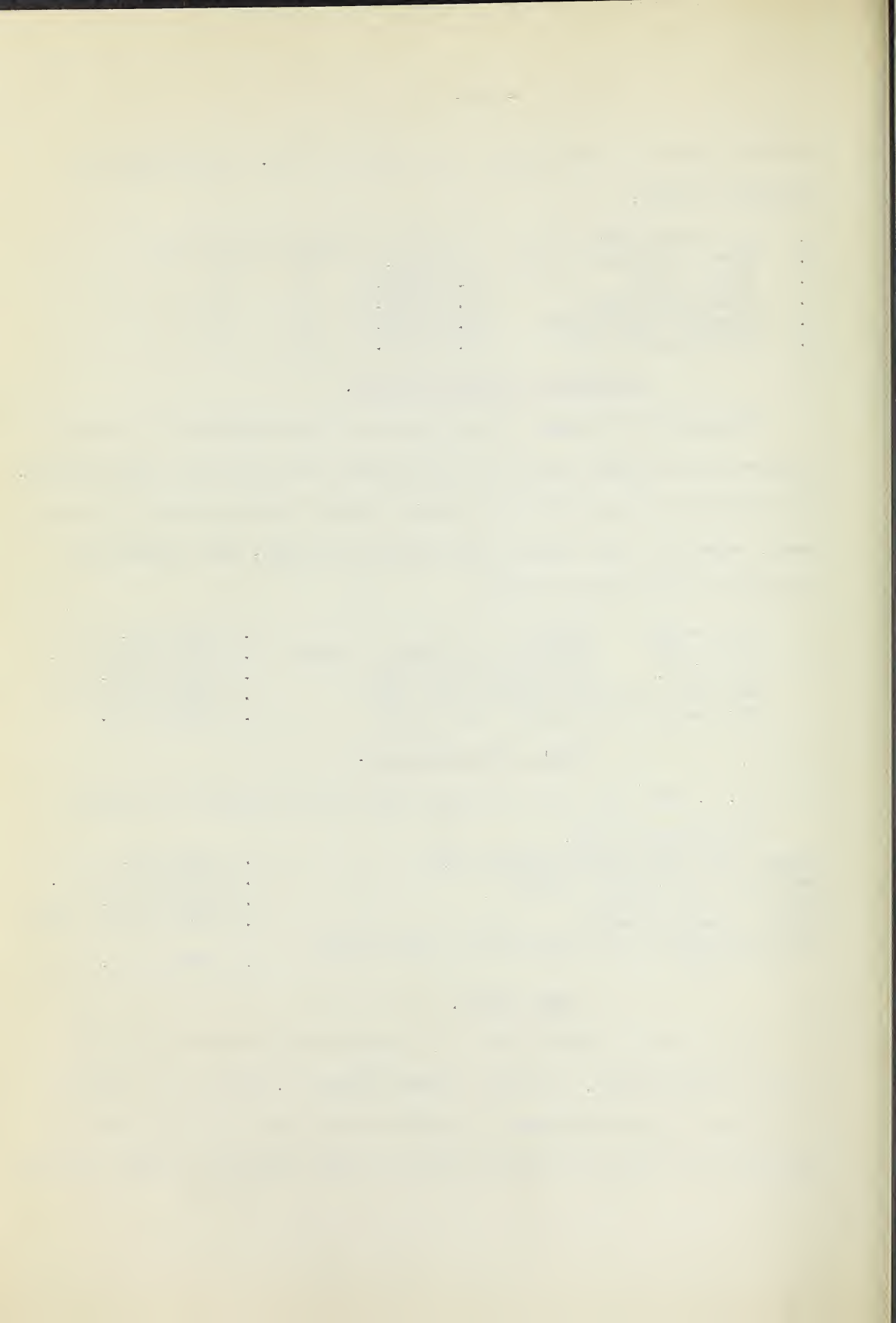
Dr. E. Muck (23) also in Germany used a similar system, as follows:

Appearance of coke.

Powder, just like the coal powder used	1. Sand coal.
Somewhat molten, partly powder	2. Molten sand coal.
Molten but not puffed	3. Sinter coal.
Molten, somewhat puffed	4. Caking sinter coal.
Thoroughly molten and puffed up in a form similar to a potato	5. Caking coal.

Fuel Ratio.

In the United States as well as in Europe attention was being given to coal classification. In 1844, Professor Walter R. Johnson, in a report to the United States Government on American coals, said that coals could be compared by the ratio of volatile matter to fixed combustible matter, volatile



matter to include moisture.

Professor H. D. Rogers (17) a short time later, sub-divided American coal in accordance with natural characteristics, into four principal groups, and gave the ordinary range of constituents. He claimed to have originated the term semi-bituminous for one of the classes. His classification recognizes three orders: anthracite, common bituminous, and hydrogenous. The divisions and limits proposed by Rogers are as follows:

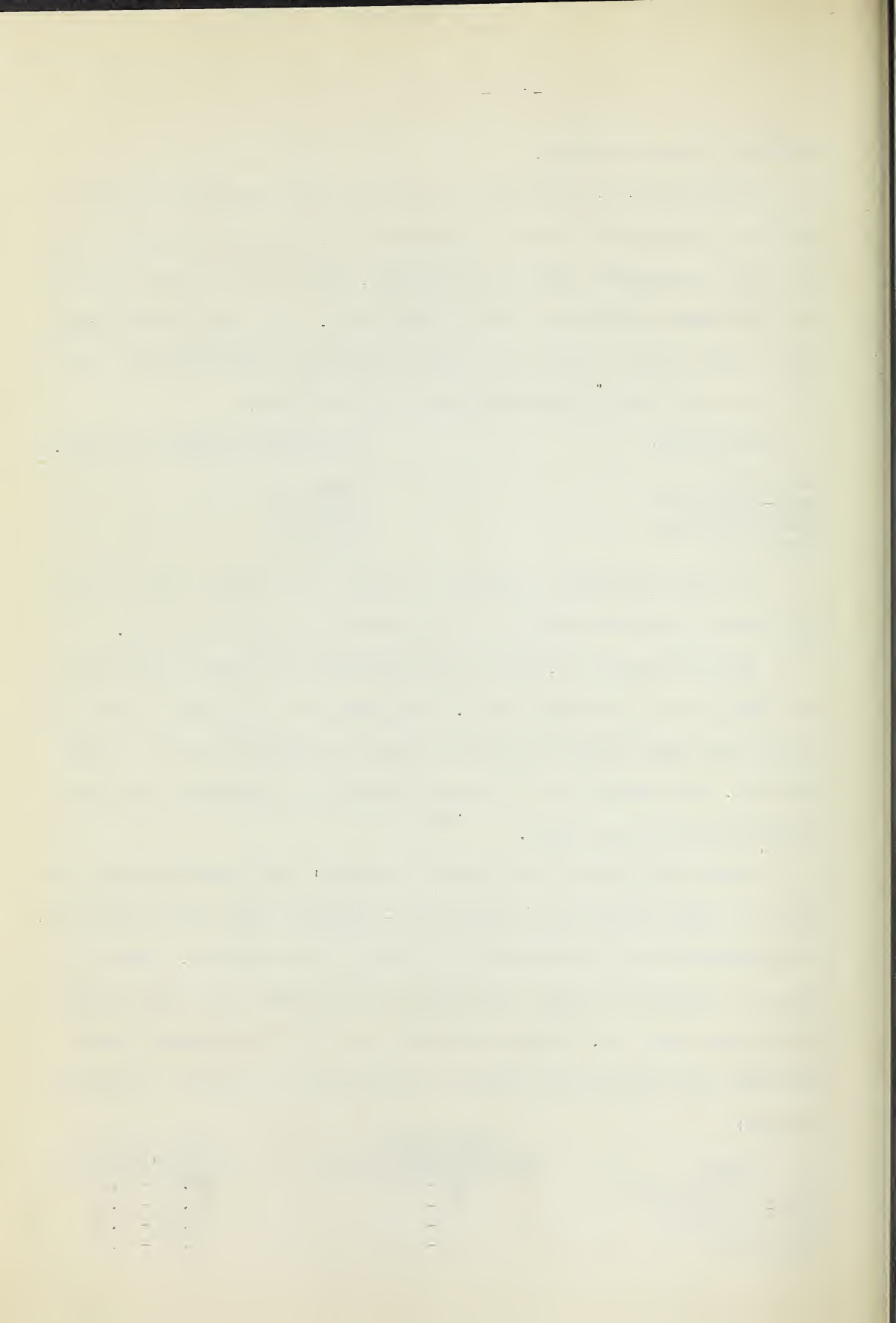
<u>Rank of coal.</u>	<u>Percentage of Volatile matter.</u>
Anthracite	Below 6
Semi-anthracite	Below 10
Semi-bituminous	12 to 18
Bituminous	Over 18

He gives the limits of ultimate analysis, but does not clear of ash, thus showing apparent variation in the combustible part of the coal.

Persifor Frazer, Jr. (17) in 1877 followed up the idea of the ratio of fixed carbon to volatile matter. His purpose was to suggest limitations to the four vague classes into which Rogers had divided the coals of Pennsylvania. The designations of classes suggested by Rogers had been quite largely adopted by the trade.

Frazer took analyses as provided in Rogers' report and determined the ratio of fixed carbon to volatile matter - commonly known as the fuel ratio. He considered other constituents of the coal to be accidental. The fuel ratios so determined showed overlapping in the classes, into which Rogers had divided the coals. To make separation into definite classes, Frazer proposed that limits of fuel ratios for the different classes be assigned as follows:

<u>Class</u>	<u>Fixed Carbon</u> <u>Volatile Hydrocarbons</u>	<u>Fuel Ratio on</u> <u>Rogers' Division</u>
Hard dry anthracite	100 - 12	67.02 - 8.61
Semi-anthracite	12 - 8	12.75 - 5.41
Semi-bituminous	8 - 5	11.41 - 3.96
Bituminous	5 - 0	3.93 - 0.68



This classification seems to have been generally adopted in the United States. It was proposed only for Pennsylvania coals which are of high rank. It has been found unsuitable for lower rank coals in other parts of the country, since no division is made for coals whose fuel ratio is below 5.

Wedding's Classification.

Wedding, a German investigator, proposed dividing coals into six groups, as shown below, according to the percentage of volatile matter in the dry, ash-free coal.

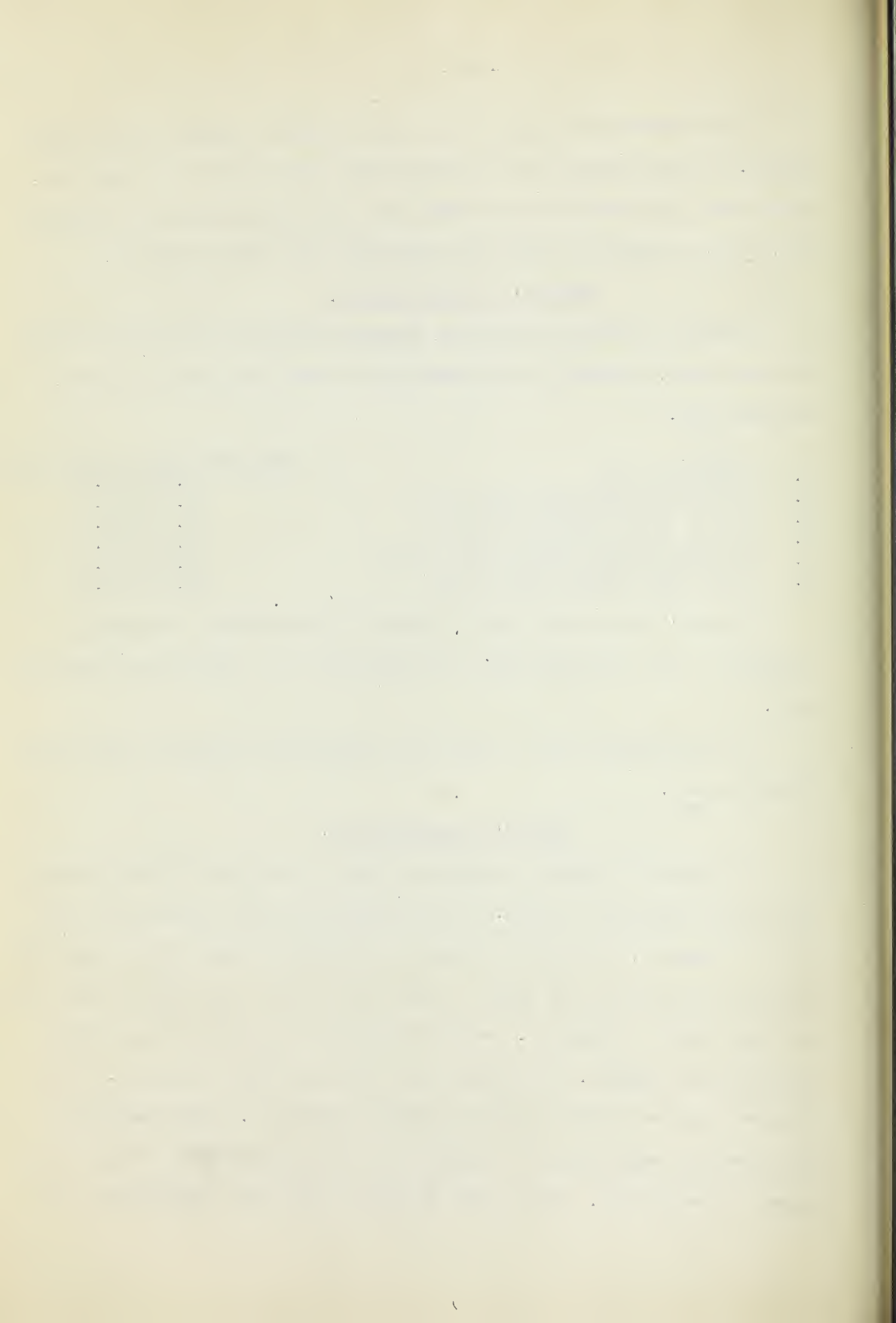
<u>Class.</u>	<u>Percentage yield of Volatiles.</u>
1. Lean anthracite	5.0 to 10.0
2. Sintering coals (old) poor in gas	10.0 to 15.5
3. Coking coals (old) poor in gas	15.5 to 33.3
4. Coking coals (recent) rich in gas	33.3 to 40.0
5. Sintering coals (recent) rich in gas	40.0 to 44.0
6. Semi coals (recent) rich in gas	44.4 to 50.0

Wedding's opinion was that in general the percentage of volatiles yielded by a coal diminishes with its geological age, a view not now generally held.

A classification such as this fails entirely when applied to the higher volatile coals.

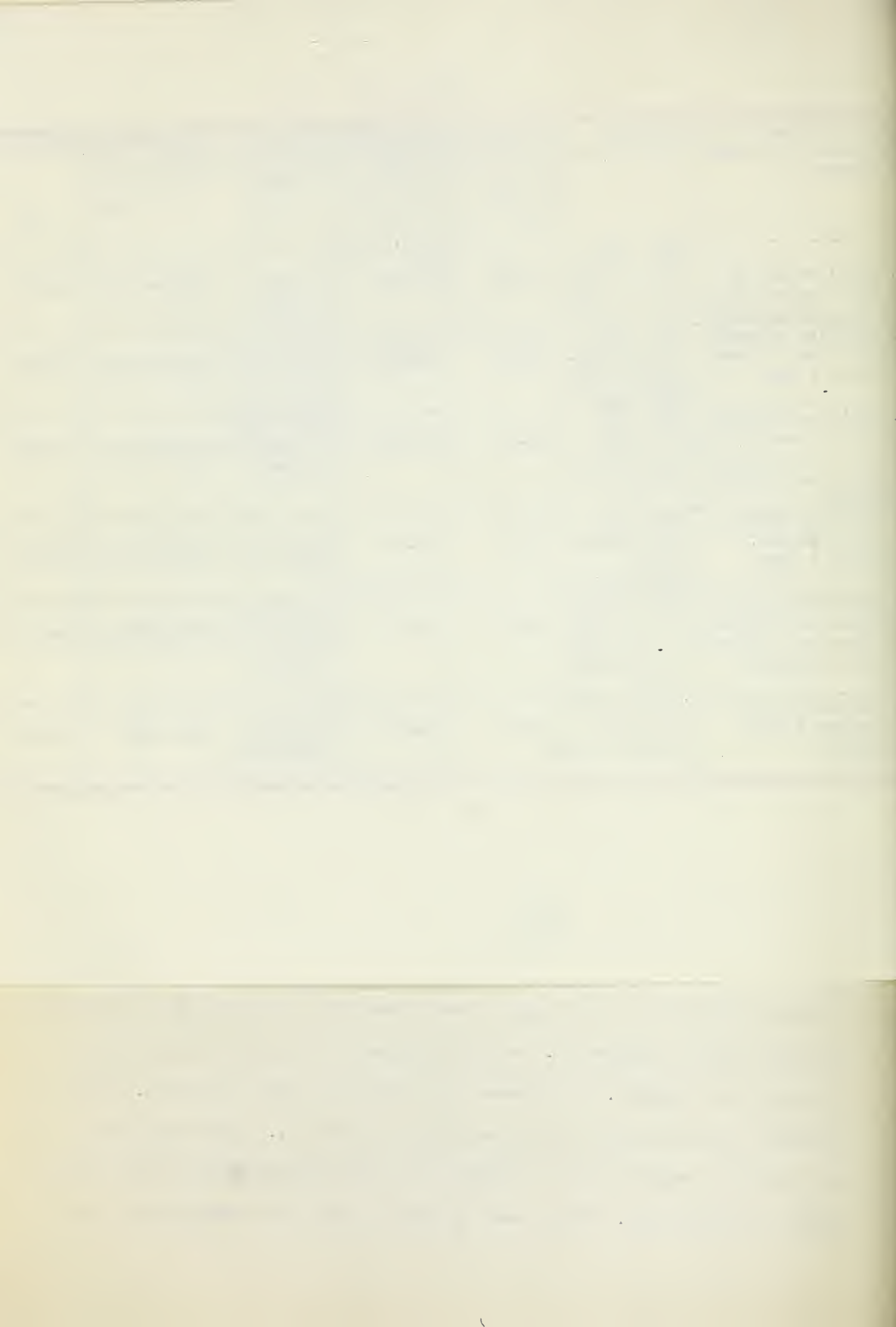
Gruner's Classification.

In Europe the ultimate composition seems to have been favored as means of defining groupings of coals. In 1873 Gruner, (26 & 4) following the lead given by Regnault, attempted to bring the properties of the various coals into relation and to define the limits of each class of coal contained in the French grouping already referred to. He distinguished five groups ranging between anthracite and lignite. His classes and limits are shown in Table I. Table II shows the same classification as revised by Bone (4). His classification was based on a small number of analyses, and his generalizations do not always agree with experience. It has been claimed by some other investigators that



T A B L E I.

Class or type of coal and commercial name in France	Assumed Translation	Proportion of coke in 100 parts of pure coal. %	Proportion of volatile matter in 100 parts of pure coal. %	Nature and appearance of coke	Real Caloric power Calories	Carbon %	Hydrogen %	Oxygen and Nitrogen %	Ratio $\frac{O + N}{H}$	Designation in Germany (Ruhr Basin)	Designation in England
1. Houilles seches (dry) a longue flamme Houilles flamboyantes	Dry, long flame bituminous coal	55-60	45-40	Powdery slightly fused	8000-8500	70-80	5.5-4.5	19.5-15.5	Between 4 & 3	Flamm-Kohle	Splint coal
2. Houilles grasses (fat) a long flamme Charbons a gaz	Fat, long flame bituminous coal Gas coal	60-68	42-32	Completely agglomerated and very often fused	8500-8800	80-85	5.8-5.0	14.2-10.0	Between 3 & 2	Gas-Kohle	Gas coal
3. Houilles grasses (fat) proprement dites Charbons de forge et Houilles marecnales (smiths)	Fat coal properly so called Smiths coal	68-74	32-26	Fused and more or less swollen	8800-9300	84-89	5.0-5.5	11.0-5.5	Between 2 & 1	Fett-Kohle	Caking coal
4. Houilles grasses a courte flamme. Charbons a coke	Fat coal with short flame Coke coal	74-82	26-18	Fused, compact	9300-9600	88-91	5.5-4.5	6.5 - 4.5	Nearly 1	Fett-Kohle	Steam coal
5. Houilles maigres (lean) ou anthraciteuses charbons demigres Charbons quartgras	Lean bituminous coal or half fat anthracitic coal	82-90	18-10	Slightly fused, very often powdery	9200-9500	90-93	4.5-4.0	5.5 - 3.0	Less than 1	Mager-Kohle	
6. Anthracites Charbon maigre (lean) Anthracite	Anthracites Lean anthracitic coals	90-92	10- 8	Powdery often decrepitated	9000-9200	93-96	4.0-2.0	3.0	1 -0.5	Anthracite	Anthracite



T A B L E I I. The Renault-Gruner Classification of Coals (As Revised by W. A. Bone)

Genus	Class	Chief Uses	Percentage Composition			% Volatiles at 900° C	% Fixed Carbon	Character of Carbonaceous Residue
			C.	H.	O + N + S			
A. Lignites	Non-caking	-	60 to 75	about 5.0	20 to 35	above 45	below 55	Non-coherent
B. Bituminous	(1) Non-caking Long flame	Reverberatory Furnaces	75 to 80	4.5 to 5.5	15 to 20	40 to 45	55 to 60	Non-coherent
	(2) Caking Long flame	Gas-making	80 to 85	about 5.6	10 to 15	32 to 40	60 to 68	Very porous coke
	(3) Hard Coking	Coke Manufac- ture	84 to 89	5.0 to 5.6	5.5 to 11.0	26 to 32	68 to 74	Dense coke
	(4) Hard Coking Short flame	Coke manufacture and steam raising	86 to 90	4.5 to 5.5	5.5 to 6.5	18 to 26	74 to 82	Very dense coke
B. C. Semi- bituminous	Non-caking Short flame	Steam raising	90 to 92	4.0 to 4.5	4.0 to 5.5	15 to 20	80 to 85	Weakly caking or Non-coherent
C. Anthracitic and Anthracites	(1) Anthracitic Non-caking	Steam raising				8 to 15	85 to 92	Pulverulent
	(2) Anthracites Non-caking	Domestic and Central heating Melting kilns	92 to 94	3.0 to 4.0	3.0 to 4.5	Below 8	above 92	

All the numerical data in the above table refer to the dry ashless coal.

there is no correlation between volatile matter and coking power, particularly when comparing different fields.

Seyler's Classification.

C. A. Seyler (30) made an intensive study of the coals of South Wales, and from the results of his study drew up his classification. He had a considerable number of ultimate analyses available. With each analysis he had a statement of the physical character of the coal, and the use for which it was best suited.

Seyler calculated these analyses to a pure coal basis, so that the sum of the percentages of carbon, hydrogen, and oxygen and nitrogen made up 100. The coals used were of low ash content, hence the error introduced owing to mineral matter not being exactly represented by ash would be small. By a graphical study of the analyses he was able to establish Regnault's thesis, that coals of a similar character fall between narrow limits of ultimate composition. Another important result was the discovery of a relation between the percentage of hydrogen and the volatile matter. He found that, for coals not too high in oxygen content, with increasing oxygen there is a regularly decreasing carbon content. So close was the correspondence between oxygen and carbon that he concluded that the percentage of carbon could well be substituted for the percentage of oxygen in Regnault's classification. Carbon has advantages over oxygen as a basis of classification, in that there is a larger range of values, and it is capable of more accurate determination. However, he also found that volatile matter and coking power could not be correlated with the carbon percentage. For example, between the limits of 90 and 93% carbon, were found coals with hydrogen varying from about 3.4 to 5.2%, and volatile matter from 6 to 24%, and every variety of coal from anthracite to coals with considerable coking power. Typical varieties of coal occurred

within a narrow range of carbon content, or in a narrow carbon plane. Just as important as this was the observation that whenever a certain percentage of hydrogen was reached the same kind of coal recurred. Acting on these two observations he divided coals into species according to their carbon content, each species having many properties in common. Using the percentage of hydrogen, he divided the species into wider groups which he called genera. An example should make this clear. A typical anthracite has carbon over 93.3% and hydrogen under 4%. Whenever the percentage of hydrogen drops below 4 (provided the oxygen is not too high) the coal resembles anthracite in many ways and Seyler calls such coals pseudo-anthracites. He cites cases of pseudo-anthracites having as low as 84% carbon. Seyler excludes coals having carbon below 84% from this scheme, as he did not consider that the laws of correlation of properties with composition held for coals so high in oxygen. He distinguished between those lower rank coals mainly on their carbon content. Coals having below 75% of carbon he classed as lignites.

The complete classification showing the limits of carbon assigned to the species, and of hydrogen to the genera is shown in Table III.

The names given to the species are:

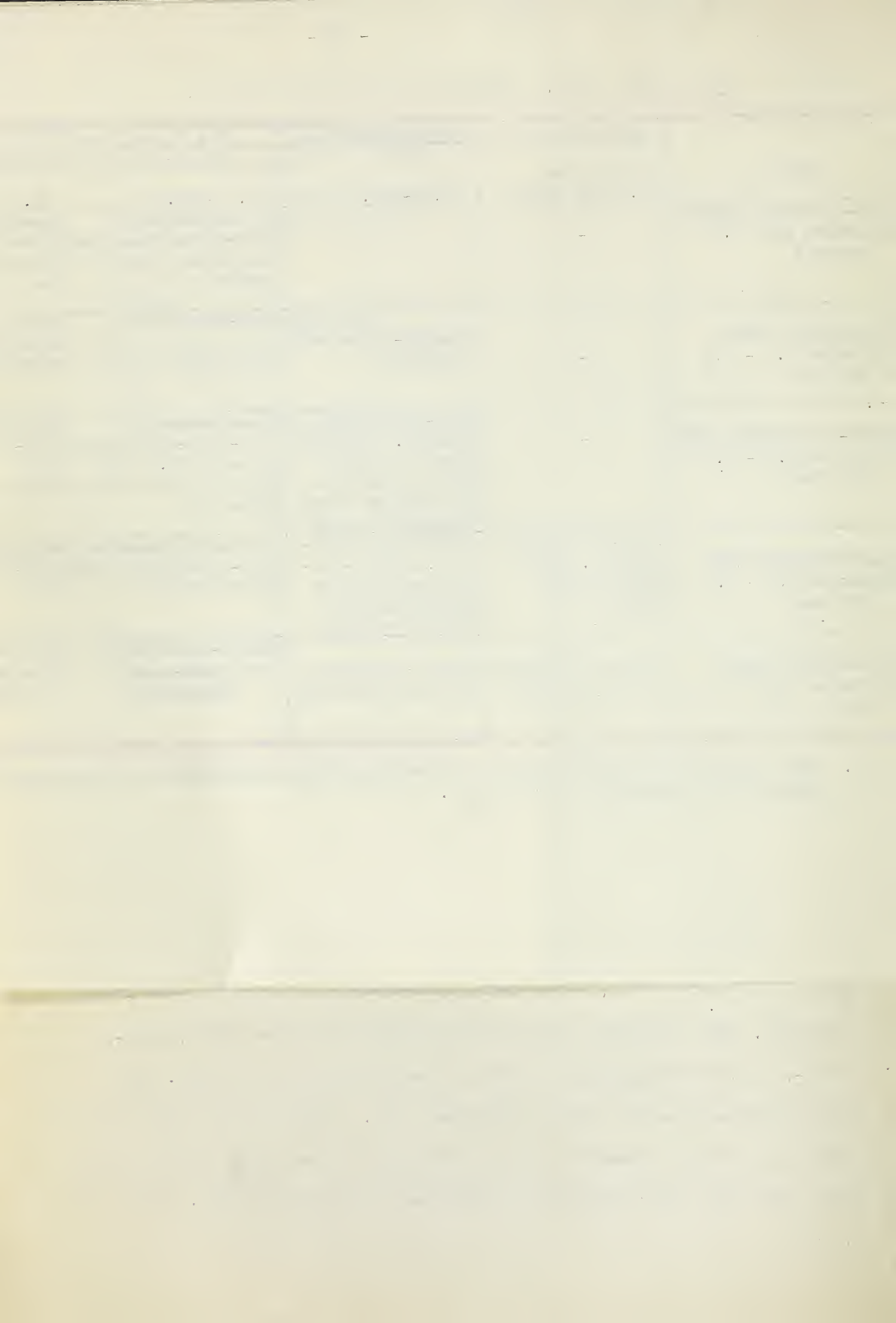
1. Anthracitic.
2. Carbonaceous.
3. Bituminous.
4. Ligniteous.

Those coals having carbon below 84% being grouped in a separate genus - the ligniteous. The bituminous genus is sub-divided into three genera, meta-, ortho-, and para-bituminous, in order of decreasing carbon content. The ortho-bituminous is the typical bituminous coal. A rise of hydrogen above the limits for typical bituminous coals is indicated by the prefix "per", while a fall below the typical hydrogen is indicated by the prefix "sub". This gives

T A B L E I I I. Seyler's Classification of Coal.

Carbon	Anthracitic	Carbonaceous	B i t u m i n o u s			Lignituous	
	Carbon over 93.3 per cent	93.3 - 91.2	Meta -	Ortho -	Para -	Meta-	Ortho-
PER-BITUMINOUS GENUS Hydrogen over 5.8 per cent	-	-	91.2 - 89.0 Per-bituminous (Per-meta-bituminous) Long flame steam coals	89.0 - 87.0 Per-bituminous (Per-ortho-bitumin- ous) Bastard cannels Gas coals	87.0 - 84.0 Per-Bituminous (Per-para-bitu- minous) Cannels Long flame steam coals	84-80 Per-Litnitous	80-75
BITUMINOUS GENUS Hydrogen 5.0 - 5.8 per cent	-	(Pseudo-bituminous species)	Meta-bituminous Welsh coking coal	Ortho-bituminous Durham coking coals Smitay & gas coals	Para-bituminous Long flame steam coals. Coking coals. Best gas coal	Lignituous (Meta-)	(Ortho-)
SEMI-BITUMINOUS GENUS Hydrogen 4.5 - 5.0 per cent	-	Semi-bituminous species. (Ortho-s semi-bituminous) Steam coals (cok- ing) Higher Index blended for coke	Sub-bituminous (Sub-meta-bituminous) House coals. Con- tinental coking when Index high	Sub-bituminous (Sub-ortho-bitumin- ous) Coking and steam	Sub-bituminous (Sub-para- bituminous)	Sub-Lignituous (Meta)	(Ortho)
CARBONACEOUS GENUS Hydrogen 4.0 - 4.5 per cent	Semi-anthracitic species. Dry (non-caking) steam	Carbonaceous spe- cies. (Ortho-car- bonaceous) Welsh smokeless steam (slight caking)	Pseudo-carbonaceous (Sub-meta-bituminous) Steam coals	Pseudo-carbonaceous (Sub-ortho-bitumin- ous)	Pseudo-carbona- (Sub-para- bituminous)		
ANTHRACITIC GENUS Hydrogen under 4 per cent	Ortho-anthracite True anthracite	Pseudo-anthracite (Sub-carbonaceous)	Pseudo-anthracite (Sub- meta- oituminous)	Pseudo-anthracite (Sub- ortho- bituminous)	Pseudo-anthracite (Sub-para- bituminous)		

N. B. The various genera are arranged in column I vertically according to the hydrogen. The species in each genus are arranged horizontally according to the carbon.



rise to three genera per-bituminous, bituminous and sub-bituminous. The prefix is used with the separate species, e.g. sub-meta-bituminous, so that there is no confusion with the term sub-bituminous as used in America as the name of a class of coal. The term "carbonaceous" is introduced for the species ordinarily known as anthracite lean, or semi-anthracite. The anthracitic species includes the true anthracites.

Seyler named the genera after the typical species in each case. They are five in number, thus:

- Anthracitic.
- Carbonaceous
- Semi-bituminous
- Bituminous
- Per-bituminous.

Cannel coals all occur in the per-bituminous genus.

Owing to the close correlation of hydrogen and volatile matter, Seyler considers that for coals having less than 24% of volatile matter, the genera can be distinguished almost as well by the percentage of volatile matter as by the hydrogen. The relation is about as follows:

- Anthracitic genus H under 4, - volatile matter under 10.
- Carbonaceous genus H 4.0 to 4.5, - volatile matter 10 to 16.
- Semi-bituminous genus H 4.5 to 5.0, - volatile matter under 16 to 24.

In the remaining genera, the bituminous and per-bituminous, the volatile matter varies too much in the different species to be capable of generalization.

Seyler also suggested terms to replace those suggested by Schondorff in his classification, (referred to above). In determining the color, the surface of the coked residue from the volatile matter determination in a platinum crucible is observed. The terms proposed and those which they are to replace, together with the characteristics of the coked residue are shown in the following table:

Surface	Colour	Consistence	Schondorff's term	Proposed term
Rough like fine sand	Black	Entirely pulverulent	Sand coal	Discretive coal
"	"	Just coherent	Sintered sand coal	Semi-accretive
"	"	Just coherent all over, flat, radial cracks in coke	Sinter coal	Accretive
"	Dull grey	Solid with bud-like projections from surface	Caking sinter coal	Semi-concretive
Smooth	Metallic grey	Solid, more or less swollen	Caking coal	Concretive

Carbon - Hydrogen Ratio.

In 1904 Marius V. Campbell (b) of the U. S. Geological Survey, considered a number of available factors from proximate and ultimate analysis, and decided that the ratio of carbon to hydrogen on the air-dried coal was the best method of differentiating between the different ranks of coal. This classification was based on thirty-seven analyses of coal from different states.

The limits proposed by Campbell for the groups are as follows:

A.	Graphite	to ?
B.	Anthracite	? to 30 ?
C.	Anthracite	30? to 26 ?
D.	Semi-anthracite	26 to 23
E.	Semi-bituminous	23 to 20
F.	Bituminous	20 to 17
G.	Bituminous	17 to 14.4
H.	Bituminous	14.4 to 12.5
I.	Bituminous	12.5 to 11.2
J.	Lignite	11.2 to 9.3
K.	Peat	9.3 to ?
	Wood	7.2

This ratio is capable of accurate determination and in the higher ranks of coal, owing to the fact that the dividend is large and divisor small, a good range of values is obtained. In the range of lower rank coals, there is no sharp distinction between lignites and bituminous coals, that, however, is not given by any chemical criterion so far suggested. The inclusion of hydro-

gen or water is introducing a non-fuel constituent, though on the other hand, it shows something of the water retaining property of the coal.

Pollard and Strahan (The coals of South Wales. Mem. Geol. Surv. England and Wales) have used the ratio of carbon to hydrogen in the dry coal as a guide in their study of progressive anthracitization in the Welsh coal field.

Ralston's Graphic Representation.

Ralston (33) in the United States calculated a large number of ultimate analyses to the pure coal basis, by eliminating moisture, ash, sulphur and nitrogen so that carbon, hydrogen and oxygen make up 100.

He plotted the value of these elements using triangular co-ordinates.

A right angle triangle was used so that the carbon percentage was on the base of the triangle, the hydrogen on the perpendicular and oxygen on the hypotenuse.

On plotting carbon against hydrogen the points representing the coals fall along a narrow band. He found that the different classes of coal fell into separate fields with very little overlapping, thus substantiating the original thesis of Regnault. He found that coking coals occupied a position near the sharp bend in the band of analyses. This is where resin content is supposed to be highest, and also where available hydrogen is highest. Ralston considered that coals were to be found with high available hydrogen and also with high hydrogen-oxygen ratio, yet they did not coke, but on the diagram coking coals fall into a group.

H. J. Rose (35) made a graphic study along the same lines as Ralston followed, of many hundreds of American and foreign coals, for which he had records of by-product yields, and coke oven tests. From this work he concluded that "all coking coals appear to fall within fairly definite chemical limits, so far as the ultimate analyses are concerned".

Parr's First Classification.

In 1906 Parr (28) published a scheme of classification which is based on the ratio of volatile carbon to total carbon, expressed as a percentage. For the lower ranks the percentage of inert volatile matter is made use of. This classification recognizes the fact that the volatile matter contains hydrogen, oxygen, and nitrogen which are not available as fuel. Total carbon and fixed carbon as determined by analysis are used in this classification. The percentage of volatile carbon is obtained by subtracting the percentage of fixed carbon from that of total carbon. The ratio used is $V.C. \times 100/C$. The percentage of inert volatile matter is obtained by subtracting from 100 the percentages of the following constituents of the coal; carbon, sulphur, ash, water, and hydrogen which is not united with oxygen (i.e. available hydrogen). To reduce this remainder to the pure coal basis it is multiplied by

$$\frac{100}{100 - (\text{ash} + \text{moisture})}$$

The limits found suitable for the different ranks of coal are as follows:

Rank	<u>Volatile carbon x 100</u> <u>Total carbon</u>	<u>Percentage of</u> <u>Inert Volatile</u>
Anthracite	below 4	
Semi-anthracite	4 to 8	
Semi-bituminous	10 to 15	
Bituminous A	20 to 32	5 to 10
Bituminous B	20 to 27	10 to 15
Bituminous C	32 to 44	5 to 10
Bituminous D	27 to 44	10 to 15
Black lignite	27 up	15 to 20
Brown lignite	27 up	20 to 30

He also introduces the term "Gross coal index", which is the weight of coal which gives 100 pounds of pure fuel. It is expressed by the formula:

$$\frac{100}{\text{Carbon} + \text{Sulphur} + \text{Combustible Hydrogen}} \times 100$$

Grout's Classification.

Grout (18) in 1907 calculated a number of ultimate analyses to the pure coal basis, so that carbon, hydrogen, and oxygen made up 100. He plotted these constituents using tri-axial co-ordinates, but did not use this as the basis of his classification. He decided that there were no natural groupings of coal, but that any group designations must be arbitrarily drawn.

Grout considered that the proximate analysis gave the best distinction for high carbon coals, and taken with the percentage of total carbon, made a very satisfactory classification. He was in favor of using more than one ratio in distinguishing between groups. His classification recognizes the following classes and fixes the limits of each as shown.

Graphite	Fixed carbon over 99%
Anthracite	Fixed carbon over 93%
Semi-anthracite	Fixed carbon 83 to 93%
Semi-bituminous	Fixed carbon 73 to 83%
Bituminous	
High grade	Fixed carbon 48 to 73%
	Carbon 82 to 88%
Low grade	Fixed carbon 48 to 73%
	Carbon 70.2 to 82%
Cannel	Fixed carbon 35 to 48%
	Carbon 70.2 to 88%
Black lignite	Fixed carbon 35 to 60%
	Carbon 73.6 to 70.2%
Brown lignite	Fixed carbon 30 to 55%
	Carbon 65 to 73%
Peat	Fixed carbon below 55%
	Carbon below 65%

The percentages are expressed on the pure coal. Grout states that the fuel ratio can be substituted for the percentage of fixed carbon.

David White (42) in a consideration of the effect of oxygen in coal found that it is equal to ash in its anti-calorific value. To compare the efficiencies of different coals he arranged them in the order of their Carbon/oxygen + ash ratios, using these values on the air dry coal.

If the arrangement were on the ash-free or mineral matter-free basis,

becoming carbon/oxygen, the ratio might be of some value as a basis of classification, though no limits have been proposed for classes.

Parr's Second Classification.

Parr (28) in 1922 advanced another scheme of classification. This system was based on the percentage of volatile matter, and on the calorific value of what he called "unit coal". The term unit coal has been explained above. By this classification coals containing up to 33% of volatile matter on the unit coal basis were subdivided on the basis of volatile matter. For those with over 33% volatile matter the calorific value was the criterion employed.

For low rank coals Parr considered that the calorific value was a safer criterion than physical properties. The limits set by this classification are as follows:

	<u>Calorific value of unit coal, B.T.U. per lb.</u>	<u>Percentage of Volatile matter</u>
Anthracite	15,000 to 15,500	0 to 10
Semi-anthracite	15,500 to 16,000	10 to 14
Semi-bituminous	15,500 to 16,000	14 to 24
Bituminous (Eastern type)	15,000 to 16,000	24 to (33-47)
Bituminous (Western type)	14,000 to 15,000	
Sub-bituminous	13,000 to 14,000	
Brown lignite	11,500 to 13,000	
Cannel	Over 15,750	47.5 up

Thom's Classification.

W. T. Thom Jr. (40) considering that the physical characteristics and use properties of low rank coals are directly related to the moisture content, modified the last mentioned classification. Thom considered that moisture eliminated between 20° and 100° C is as much a part of the coal as that eliminated in the determination of the volatile matter, so he fixed on the air dry coal as being capable of best representing the true condition of the coal. Thom says that the low rank coals show an overlapping by both Seyler's and

Parr's classifications, while he considers that the personal equation enters too much into such a scheme as that of the United States Geological Survey.

Thom plotted the calorific value of the air dry, ash-free coal against the sum of the volatile matter and moisture on the same basis. He thought that the air dry moisture best distinguished between accidental moisture and that forming an integral part of the coal. Unstandardized methods of air drying make this classification open to the same objections as others based on air dried coal.

Stansfield's Classification.

E. Stansfield (37) also considered that Parr's scheme of using calorific value and volatile matter of "Unit" coal did not sufficiently differentiate between the lower rank coals, since coals with large difference in moisture content were quite similar when compared on the pure coal basis. In his scheme of classification proposed for discussion in 1925, he used the percentage of volatile matter and the calorific value of the coal, adjusted to a mineral matter content of 11% on the dry coal, (for reasons already explained) and readjusted to the percentage of moisture in the coal as mined. An ash content of 10% was taken as equivalent to a mineral matter content of 11%.

The classes and limits proposed by Mr. Stansfield are as follows:

Class	Calorific value of coal moisture as mined with adjusted ash	Volatile matter (same basis)
Short flame bituminous	above 12,700	below 20%
Long flame bituminous	above 12,700	above 20%
Sub-bituminous	10,700 to 12,700	
Black lignite	8,200 to 10,700	
Brown lignite	below 8,200	

In later work, as yet unpublished, Mr. Stansfield has employed the sum of the moisture and volatile matter in the coal as mined, adjusted for

ash as explained above, in graphical representation of the different coals of the province.

Ashley's Classifications.

Ashley has advanced two different Use Classifications of coal. In the earlier classification the higher rank coals are distinguished by their fuel ratio, and the lower ranks by the ratio of the moisture "as received" to fixed carbon. The woody character of low rank coals is also considered.

The ratios are chosen because in the higher ranks of coal the moisture changes little and the volatile matter much in relation to fixed carbon, while in the lower ranks there is a larger proportionate change in the moisture than in the volatile matter, with respect to the fixed carbon.

For the purposes of this classification all coals are first divided into those of compact texture and those of woody, fibrous, or earthy texture. The subdivisions of these two classes are shown in the following tabular statement of the classification.

Coals of compact texture.

1. Anthracite, fuel ratio 7 plus, non-luminous flame.
 - (a) True hard anthracite, fuel ratio 10 plus, conchoidal fracture.
 - (b) Soft anthracite, fuel ratio 7 to 10, semi-cubic fracture.
2. Bitumite, fuel ratio less than 7, luminous flame.
 - A. Calorific value over 14,300 B.T.U. per pound, on moisture, ash, and sulphur free basis.
 1. Fuel ratio 2.5 to 7, smokeless coal, short to medium flame.
 - (a) Fuel ratio 5 to 7, non-caking household and caking steam coal.
 - (b) Fuel ratio 3.5 to 5, caking coal.
 - (c) Fuel ratio 2.5 to 3.5 caking coal.
 2. Fuel ratio below 2.5, long flame.
 - (a) Fuel ratio 1.4 to 2.5, caking long flame.
 1. Fuel ratio 1.85 to 2.5.
 2. Fuel ratio 1.4 to 1.85
 - (b) Fuel ratio under 1.4
 1. Fixed carbon-moisture ratio 6 plus.
 - a. Fixed carbon-moisture ratio 10 plus.
 - b. Fixed carbon-moisture ratio 6 to 10.
 2. Fixed carbon-moisture ratio below 6, (contains high moisture coals)

- B. Calorific value less than 14,300 B.T.U. per pound.
This class consists of bituminous and sub-bituminous coals which are separated on the basis of weather resisting properties. Most sub-bituminous have fixed carbon-moisture ratio 1.0 to 2.0.

Coals of woody, fibrous or earthy texture.

This class includes lignites having fixed carbon-moisture ratio, 0.5 to 1.0

Each of these classes and sub-classes is given the name of a state or county of which it is the typical coal, e.g. those with fuel ratio 1.4 to 2.5 he designates as Pennsites, from their abundance in Pennsylvania. The two sub-divisions of this group are known as Connelssite and Pittssite, from the Connelssville and Pittsburg districts.

Ashley's second classification, which was proposed for the consideration of the committee of American Engineering Standards on Coal Classification, is based on the percentage of fixed carbon in the ash free coal as mined.

He justifies this theoretically on the assumption that the process of coal maturing may be considered as a progressive elimination of volatile matter, including moisture, the proportion of remaining fixed carbon forming a regularly ascending series from one end of the process to the other.

He considered that each of the common commercial classes of coal as high volatile, medium volatile and low volatile, etc., as mined, cover a range of about seven per cent of fixed carbon. Hence coals can be designated as: Coal 28, Coal 35, Coal 42, etc., up to Coal 70 or 77 or 84. Coal 70 being a coal with from 70 to 77% fixed carbon on the ash-free, as mined, basis. Letters are appended to show grading in the class, e.g. A. B. C. and D. express four grades of ash content, F. G. H. and I. express four grades of temperature of fusion of ash, S. T. U. and V. four grades of sulphur content. K. represents cannel, X. non-caking, Z. sub-bituminous. Names are introduced for each of the classes, e.g. lowvol, midvol, hivol and moistvol.

Campbell's Physical Classification for Low Rank Coals.

In 1908 Campbell (8) proposed a scheme, based on physical properties and characteristics, for differentiating between low rank coals. Two groups are recognized below the rank of bituminous, they that are known as black lignite, until 1908 when the U. S. Geological Survey adopted the term sub-bituminous for that class, and the other known as brown lignite. Campbell's scheme is based on the theory that the change from wood to lignite and other ranks of coal was due to chemical change caused by heat and controlled by the rate of escape of the gases produced. If the gases escaped unimpeded the coal would be highly developed, if impeded the coal would not become so metamorphosed. To separate bituminous from sub-bituminous, he took lack of cleavage planes to denote a low rank coal. An exception to this rule occurs where strong forces had acted to produce well developed cleavage when the coal was still too young to have been metamorphosed to bituminous.

The manner of fracture on driving was also suggested. In bituminous coals on weathering, the prismatic shape persists until small pieces are reached. Sub-bituminous checks irregularly on exposure, giving fragments with rough irregular faces. It does separate into plates parallel to the bedding plane of the seam. The black color alone is used to distinguish between sub-bituminous and brown lignite.

Dowling's Split Volatile Ratio.

Dowling (12) in his geological survey report, advanced a classification by means of which he hoped to get a division similar to that given by Campbell's carbon-hydrogen ratio. His so-called, "Split Volatile Ratio" was decided upon. He had only a few ultimate analyses to work on, while several proximate analyses were available.

The Split Volatile Ratio is expressed by the formula:

$$\frac{\text{Percentage of fixed carbon} + \frac{1}{2} \text{ percentage of volatile matter}}{\text{Percentage moisture} + \frac{1}{2} \text{ percentage of volatile matter}}$$

All percentages were to be expressed on the air dried basis. Most of the samples made use of for analysis, he considered to be approximately air dried by exposure to the air before being analysed. This classification, and others based on the air dry coal, introduce too much error owing to un-standardized methods of air-drying.

U. S. Geological Survey Classification.

In a paper (21) given at the International Conference on Bituminous Coal held at Pittsburgh in November 1926, M. R. Campbell outlined the classification adopted by the U. S. Geological Survey. He also showed a chart giving the proximate analysis and calorific value of coals typical of each class. The chart is reproduced in Plate I. The classes recognized with the characteristics of each are as follows:

Peat: approximate constituents 85% moisture, 10.4% volatile matter, 4.6% fixed carbon, and calorific value 1,290 B.T.U.

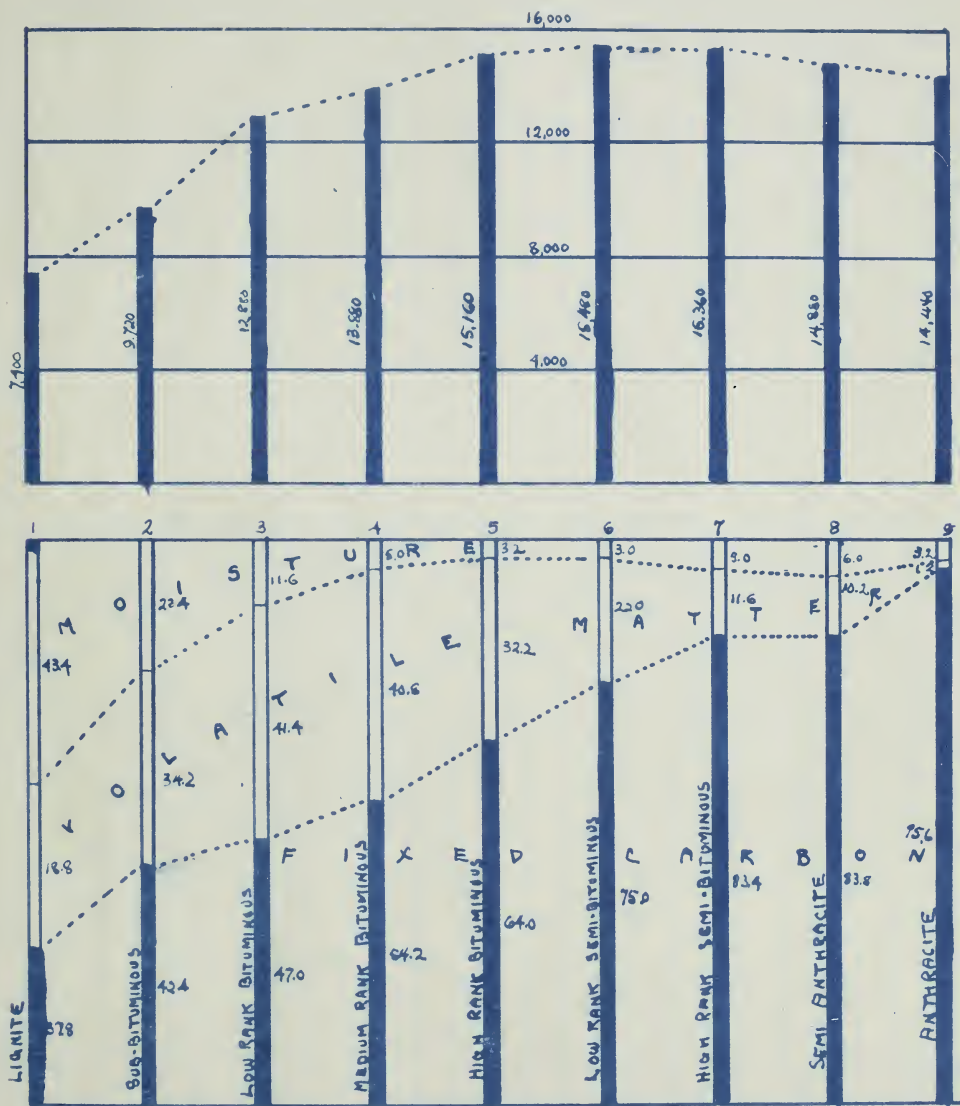
Lignite: brown in color, woody or composed of finely divided plant tissues, or amorphous and representing the first stage in the development of cannel. Contains 25% to 45% moisture, and on drying shrinks and breaks up in an irregular manner. Calorific value ranges from 6,000 to 7,500 B.T.U.

Sub-bituminous: moisture 12 to 25%, black in color, slacks on exposure to the weather, Calorific value 7,000 to 11,000 B.T.U.

Bituminous: little slacking on exposure to weather. Calorific value 11,000 to 15,000 B.T.U. Fuel ratio below 2.5 - the class includes cannels, some of the best steam coals, and the best gas and by-product coal.

Semi-bituminous: fuel ratio 2.5 to 5. Calorific value 12,000 to 15,400; nearly smokeless, usually friable and breaks down easy.

Semi-anthracite: fuel ratio 5 to 10, harder than bituminous but not



P L A T E I.

Diagrams Showing the Effects of the Progressive Metamorphism of Vegetal Matter from Peat to Super-Anthracite. The Lower Diagram Represents the Chemical Composition (except Ash) and the Upper Diagram, the Heating Values in B.T.U.

so hard as anthracite, burns with a short yellow flame at first, then with blue flame after volatile matter is given off.

Anthracite: fuel ratio over 10, hard, heavy, burns with a blue flame, is difficult to ignite, burns without smoke, does not soil.

The Executive Committee of the Twelfth Session of the International Geological Congress, made coal the chief subject for discussion at that session. A special committee drew up a classification system which was used in determining the nature and extent of the coal resources of the various countries. Coals were divided into four classes, designated by the letters A, B, C, and D. Three of these classes had subclasses, so that in all eight divisions or ranks of coal were recognized.

The classes and subclasses with the characteristics of each, are given in the following table:

Class A.

1. Burns with short, blue flame; gives off 3 to 5% of volatile combustible matter.

Fuel ratio $\frac{\text{Fixed carbon}}{\text{Volatile matter}} = 12 \text{ and over}$

Calorific value 14,500 to 15,000 B.T.U. per pound.

Mean composition:

Carbon	93 to 95%
Hydrogen	2 to 4
Oxygen and nitrogen	3 to 5

2. Burns with slightly luminous, short flame and little smoke; does not coke and yields from 7 to 12% of volatile matter.

Fuel ratio, 7 to 12.

Calorific value generally 15,000 to 15,500 B.T.U.

Mean composition:

Carbon	90 to 93%
Hydrogen	4 to 4.5
Oxygen and nitrogen	3 to 5.5

Class B.

1. Burns with short, luminous flame and yields 12 to 15% volatile matter; does not readily coke.

Fuel ratio 4 to 7.

Calorific value generally 15,200 to 16,000 B.T.U.

Mean composition:

Carbon	80 to 90%
Hydrogen	4.5 to 5
Oxygen and nitrogen	5.5 to 12

2. Burns with luminous flame and yields from 12 to 26% volatile matter; generally cokes.

Fuel ratio 1.2 to 7.

Calorific value 14,000 to 16,000 B.T.U.

Mean composition:

Carbon	75 to 90%
Hydrogen	4.5 to 5.5
Oxygen and nitrogen	6 to 15

3. Burns freely with long flame; withstands weathering, but fractures readily, and occasionally has moisture content up to 6%; volatile matter up to 35%; makes porous, tender coke.

$$\frac{\text{Fixed carbon} + \frac{1}{2} \text{volatile}}{\text{Hygroscopic moisture} + \frac{1}{2} \text{volatile}} = 2.5 \text{ to } 3.3$$

Calorific value 12,000 to 14,000 B.T.U.

Mean composition:

Carbon	70 to 80%
Hydrogen	4.5 to 6
Oxygen and nitrogen	18 to 20

Class C. Cannel.

Burns with long, smoky flame; yields from 30 to 40% volatile matter on distillation, leaving very porous coke. Fracture generally resinous. Calorific value 12,000 to 16,000 B.T.U.

Class D. Sub-bituminous.

Contains generally over 6% of moisture, disintegrates on drying; streak brown or yellow; cleavage indistinct.

1. Moisture in fresh-mined, commercial output up to 20%. Fracture generally conchoidal. Drying-cracks irregular, curved lines. Colour generally lustrous black, occasionally brown.

$$\frac{\text{Fixed carbon} + \frac{1}{2} \text{volatile}}{\text{Hygroscopic moisture} + \frac{1}{2} \text{volatile}} = 1.8 \text{ to } 2.5$$

Calorific value 10,000 to 13,000 B.T.U.

Average composition:

Carbon	60 to 75%
Hydrogen	6 to 6.5
Oxygen and nitrogen	20 to 30

2. Moisture in commercial output over 20%. Fracture generally earthy and dull. Drying-cracks generally separate along bedding planes and often show fibrous (woody) structure. Calorific value 7,000 to 11,000 B.T.U.

Average composition:

Carbon	45 to 65%
Hydrogen	6 to 6.8
Oxygen and nitrogen	30 to 45

Fisher's Diagrams.

D. J. Fisher of the University of Chicago, has recently suggested two new ideas in the way of coal classification. He has drawn two triaxial diagrams, the one based on the proximate constituents, and the other on the ultimate analysis. His purpose is to show the loss by coal of certain substances during the coalification process. Fisher used the "as-received" basis, and calculated his analyses to the ash-free basis for his graphical representations.

In the first scheme Fisher plots the percentages of moisture, volatile matter, and fixed carbon in the coal ("as received" ash-free), using equilateral triaxial co-ordinates. The diagram shows that in the earlier stages the process of coalification is mainly one of dehydration, while in the later stages it is mainly one of devolatilization. The dehydration process is the most important process up to about the early bituminous stage, after which it is practically supplanted by the devolatilization process.

The second scheme shows the ultimate analyses constituents; - carbon, hydrogen, and oxygen - on the as received ash-free coal. From the diagram deoxidation is the most important process of coalification, though dehydrogenation is important in the earlier and later stages.

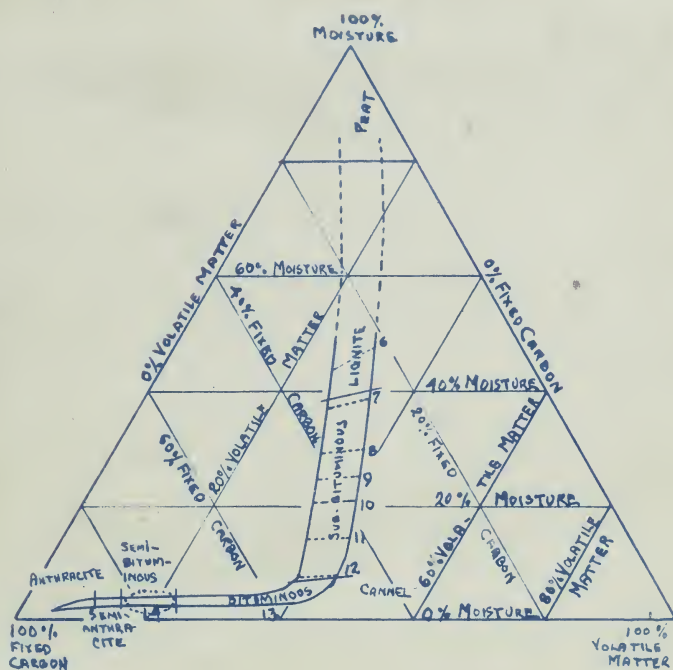
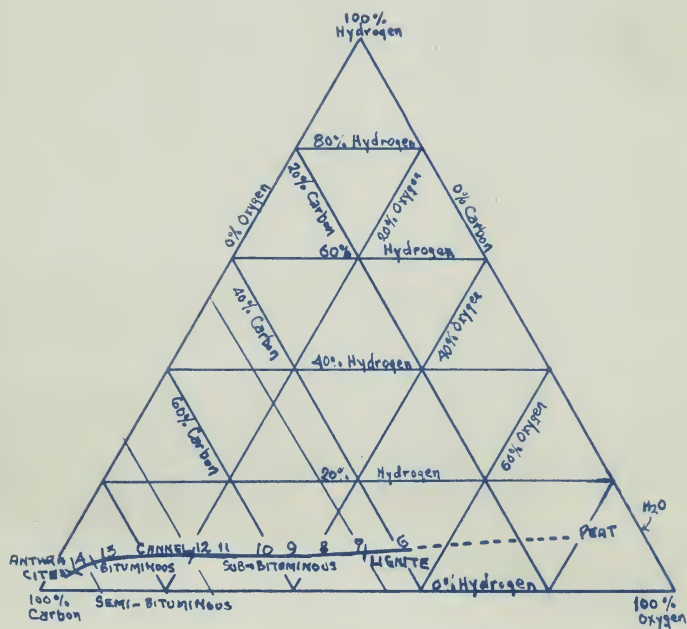


FIGURE I.
Fisher's Coal Series - Proximate Analysis, as received. Calculated ash-free.



F I G U R E I I .

Fisher's Coal Series - Ultimate Analysis, as received, calculated ash-free.

Summary.

From the foregoing description of the different classifications which have been proposed, it will have been seen that classifications have been based on the data obtained by both proximate and ultimate analysis and on combination of both, and also on other criteria. They have been founded on data on the moist, air dry, and dry coal bases of both proximate and ultimate analysis. Table 4 gives a summary of the classifications mentioned, with the criteria employed in each.

A general consideration of the relative accuracy and reliability, as well as ease of application, of the different bases and criteria should be given at this point.

A classification based on data obtained by the proximate analysis has the obvious advantage that the data is easily and quickly obtained. On the other hand the proximate analysis is not the determination of either definite compounds or chemical elements, but is the determination of arbitrary values. Carefully standardized procedure is required in order that the results obtained in all laboratories may be comparable; e.g. if the temperature used in the determination of the volatile matter be raised 100°C above the standard temperature, a higher yield of volatile will be obtained.

A classification based on the ultimate analysis requires tedious and expensive determinations, but being determinations of chemical elements, they are not based on arbitrarily standardized procedure, and hence results obtained vary only within experimental error. However, for reasons already explained, care must be exercised in the interpretation of the results of the ultimate analysis.

Neither proximate nor ultimate analysis determines the actual com-

T A B L E I V. Summary of Methods of Coal Classification.

Classification	Basis of Classification
Hilt	Volatile matter as a percentage of fixed carbon
Frazer	Ratio $\frac{\text{Fixed Carbon}}{\text{Volatile matter}}$
Dowling	Ratio $\frac{\text{Fixed Carbon} + \frac{1}{8} \text{ Volatile Matter}}{\text{Moisture} + \frac{1}{8} \text{ Volatile Matter}}$ on air dry coal
Parr (2)	Calorific Value and Volatile Matter of pure coal
Thom	Calorific Value and Gross Volatile Matter of air dry, ash-free coal
Stansfield	Calorific Value and Volatile Matter of moist coal with adjusted ash
Ashley (1)	Ratios $\frac{\text{Fixed Carbon}}{\text{Volatile Matter}}$ and $\frac{\text{Fixed Carbon}}{\text{Moisture}}$
Ashley (2)	Percentage of fixed carbon in moist ash-free coal
Fisher	Triaxial diagram showing moisture, volatile matter, and fixed carbon in moist ash-free coal.
Regnault	Oxygen + Nitrogen in pure coal
Fleck	Disposable and combined hydrogen
Seyler	Ultimate analysis of pure coal
Campbell (1)	Ratio $\frac{\text{Carbon}}{\text{Hydrogen}}$ on air dry coal
Schondorff & Muck	Appearance of coke from volatile matter determination
Gruner	Ultimate analysis and percentage of volatile matter
Parr (1)	Ratio $\frac{\text{Volatile Carbon}}{\text{Total Carbon}} \times 100$, also inert volatile matter
Grout	Fixed Carbon and total carbon of pure coal
Campbell (2)	Physical characteristics of low rank coals
U.S. Geological Survey	Proximate analysis, calorific value and physical properties.
12th International Congress	Proximate and ultimate analysis

T A B L E I V.

nounds present, nor the proportions of different kinds of compounds in the coal. To obtain a really satisfactory classification, it would seem that some method of determining, or of finding out something about the different compounds making up the coal is required. Extraction with solutions such as chloroform, pyridine, etc. may give some indication of the nature of the coal; also, oxidation work on the ulmin content of the coal may provide some better method of classification.

Classifications using both ultimate and proximate analysis have been based on the coal, moist*, air dry, and dry.

The air-drying of coal is an arbitrary procedure for which a standard method of procedure has not been adopted in all laboratories. Hence the air dried basis is not a satisfactory one upon which to base a classification.

In calculating an analysis to the dry basis, the loss in weight sustained by the coal when heated at 105-7° C is considered as the moisture present in the coal. This is an arbitrary procedure. There is no way of determining whether this water is present as water - bound or otherwise - in the original coal, or whether it is produced by the breaking down of unstable compounds in the coal. This shows a possible defect in any classification which makes use of the moisture of the coal, or which is based on the so-called "dry" coal.

Relatively few classifications have been based on the moist coal. Several facts seem to point to this basis as the logical one upon which to found a classification. The water of the vegetation from which coal is produced is considered to be an integral part of those plants, hence should be regarded as being an integral part of the coal. It is generally considered

* "Moist" when used in this thesis, in this connection, refers to the coal moist as mined, calculated to a mineral matter free basis.

that, in the metamorphosis of coal from peat towards anthracite, dehydration is one of the most important changes the coal undergoes. Hence, it is difficult to think of the moisture content being other than part of the coal. The physical properties - such as weathering - of coals are directly related to the moisture content. From a consideration of these factors, it would seem that the logical basis upon which to found a classification of coal is the moist coal.

The moisture content of mine samples of Alberta coals, has been found to vary very little between successive samples from the same mine, or even from the same township. This would indicate that the water makes up an integral part of the coal rather than that it varies with the moisture conditions of the mine or part of the mine. Table V, showing the percentages of moisture in mine samples of coal from two townships, shows the small variation between samples. The samples from the Drumheller township were taken from eight different mines in three different seams.

T A B L E V.

Township	Area	Percentage of Moisture by Years						Average of Township
		1922	1923	1924	1925	1927	1928	
53-24	Edmonton	24.7			25.1		24.5	
		24.5			24.8			
		23.7			24.1			
		24.7			23.9			
		25.0			25.3			
					23.8			
					24.3			
					24.7			
					24.4			
					25.7			
					26.7			
					25.4			
		Average variation from average						
29-20 W 4th	Drumheller		18.9	19.6		17.9	19.2	
			19.0	19.5		17.9		
			18.1	19.2				
			19.8	19.5				
			17.4	20.5				
			18.9	20.7				
			19.0	20.6				
			20.1	18.0				
			19.4	18.7				
			19.8	19.4				
			18.8	18.1				
			19.3					
			19.8					
			19.6					
			19.5					
			19.1					
			20.6					
			19.8					
			20.4					
			19.2					
Average variation from average							19.2% 0.6	

C H A P T E R I I . I .

THE CLASSIFICATION OF ALBERTA COALS.

A considerable amount of work has been done on the classification of Alberta coals. The Alberta Provincial Mines Branch employs a classification which divides the coals now being produced in the province into three classes: bituminous, sub-bituminous, and domestic. The Atlas of the Coal Resources of the World, contains a map showing the coal fields of the Province of Alberta according to the class of coal. E. Stensfield has proposed the classification outlined above, and has plotted charts showing how calorific value and moisture content of Alberta coals vary with the locality in which they occur.

The following table shows the arrangement adopted by the Alberta Mines Branch:

Title of Class	Anthracite	Bituminous	Sub-bituminous	Domestic
Areas by classes				
Kootenay horizon	Cascade (Bankhead)	Brule Mountain Park Nordegg Cascade Crowsnest Oldman		
Belly River horizon			Halcourt Coalspur Saunders Pekisko Pincher	Sexsmith Magrath Lethbridge Taber Milk River Pekowki Redcliff Brooks
Edmonton horizon				Fanning Edmonton Tofield Camrose Castor Sheerness Ardley Big Valley Carbon Drumeller Gleichen Champion



A good example of the need of a standard classification of Alberta coals is furnished by the fact that the Atlas of the Coal Resources of the World show the Lethbridge district as being in an Anthracite and Bituminous coal area, while the Provincial Mines Branch classify the same coal as Domestic.

The tables and figures following show data and graphic representations of classifications with points to represent Alberta coals.

They are shown in the following table:

Table VI	Ratios and percentages by mines of the Kootenay horizon
Figure III	Points on Seyler's Classification to represent coals of the Kootenay horizon.
Table VII	Ratios and data of the Belly River and Edmonton horizons arranged by areas.
Table VIII	Ratios and data of coals of the Belly River and Edmonton horizons arranged in order of decreasing calorific value of the moist coal calculated mineral matter free.
Table IX	Order into which coals of the Belly River and Edmonton horizons fall by different criteria - arrangement being as in Table VIII
Figure IV	Seyler's Classification applied to Alberta coals.
Table X	Distribution by areas of the classes of coal as arranged by Seyler's Classification.
Figure V	Parr's second Classification applied to Alberta coals.
Table XI	Distribution by areas of the classes of coal as arranged by Parr's second Classification.
Figure VI	Thom's Classification applied to Alberta coals.
Table XII	Distribution by areas of the classes of coal as arranged by Thom's Classification.
Figure VII	E. Stensfield's Classification applied to Alberta coals.
Table XIII	Distribution by areas of the classes of coal as arranged by E. Stensfield's Classification.



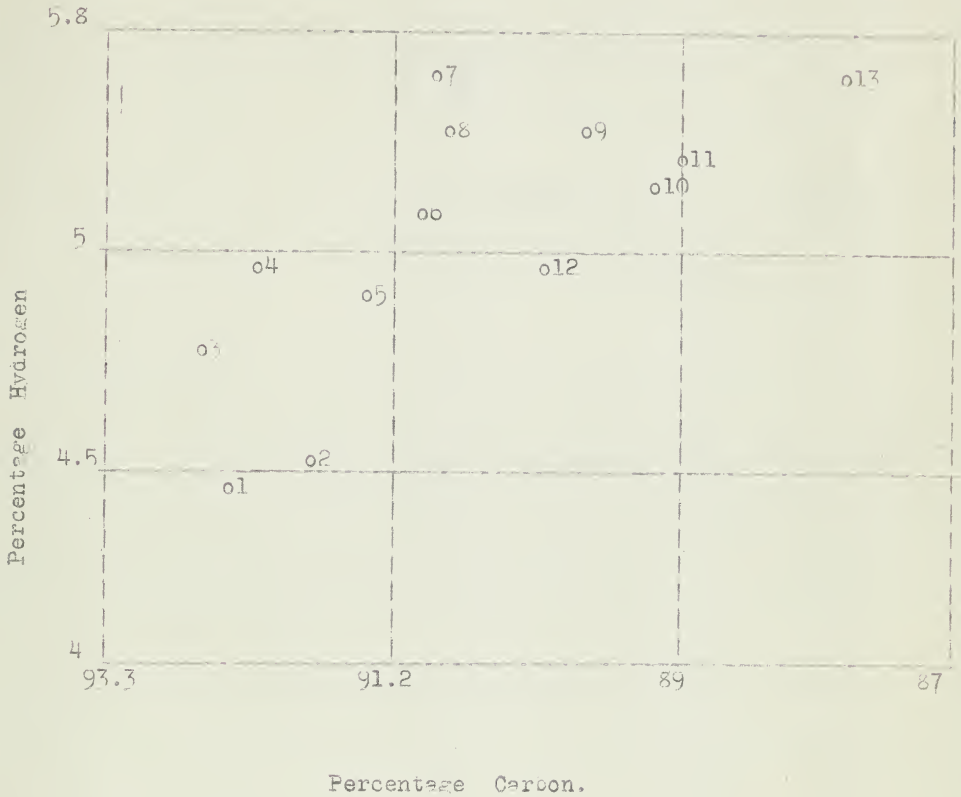
- Figure VIII Graphical Representation of Alberta coals showing calorific value and gross volatile matter of moist coal calculated to mineral matter free basis.
- Figure IX Graphical Representation of the proximate analysis of Alberta coals (moist, calculated to the mineral matter free basis)
- Figure X Scheme proposed by Fisher with points to represent Alberta coals and Fisher's division into classes.
- Table XIV Distribution by areas of the classes of coal as arranged by Dowling's Split Volatile Ratio.
- Table XV Distribution by areas of the classes of coal as arranged by the Carbon-Hydrogen ratio.
- Table XVI Distribution by areas of the classes of coal as arranged by Grout's classification.
- Table XVII Distribution by areas of the classes of coal as arranged by Parr's first classification.

T A B L E V I.

Ratios and Percentages by Mines of the Kootenay Horizon.

Area	Mine	Fuel Ratio	Split Volatide Ratio	Volatile Matter moistcoal	Volatile Matter drycoal	V.C.x100 Carbon	C/H Air dry coal	B.T.U. moist coal	Oxygen pure coal	Ignition Temperature
Cascade	Cannore (C)	5.37	10.2	15.6	15.8	7.8	20.4	15,360	1.80	235.0
	" (S)	5.16	10.1	16.1	16.2	8.3	19.9	15,550	2.10	232.5
Nordegg	Braveau	4.57	9.2	17.5	17.9	10.7	18.8	15,590	1.65	223.0
Brule	Blue Diamond	4.46	9.0	18.2	18.5	15.4	18.2	15,730	1.64	222.5
Mt. Park	Luscar	3.16	7.7	20.5	21.6	15.0	18.2	15,380	2.56	225.5
Crowsnest	Greenhill	3.02	6.6	24.3	24.8	18.0	16.6	15,470	3.20	220.4
Oldman	Skeen (14-4)	3.00	6.4	23.9	24.9	16.0	17.7	14,960	4.05	212.5
Crowsnest	To. 7-b	2.95	6.2	24.3	25.3			14,930		-
Crowsnest	Cardale	2.81	6.2	25.8	26.2	18.5	16.4	15,370	4.45	213.5
"	Dennison	2.68	5.9	26.7	27.2	18.5	17.6	15,330	2.80	218.4
"	Burmis	2.61	5.6	26.1	27.7			14,640		-
Mt. Park	Cadomin	2.57	5.7	26.4	28.0	19.7	16.9	15,400	3.45	214.3
Crowsnest	Bellevue	2.47	5.5	28.4	28.8	18.4	16.7	15,360	4.30	-
"	Hillcrest	2.29	5.2	29.7	30.2	18.5	17.0	15,460	5.59	208.5
Mt. Park	Mt. Park	2.10	4.9	31.5	32.2	23.3	15.6	15,270	5.90	207.2
Crowsnest	Tr.(6-2W5)	1.94	4.4	32.5	34.0			14,900		
"	Tr.(5-1W5)	1.87	3.9	32.3	34.8			13,700		

Figure showing the position of the coals in Table VI when plotted by Seyler's Classification.



- | | |
|--------------------------------|------------------------|
| 1. Canmore Carey | 8. Cadomin. |
| 2. Canmore Stewart | 9. Bellevue |
| 3. Canmore Brasseur | 10. Carbondale. |
| 4. < Blue Diamond | 11. Hillcrest |
| 5. Canmore Luscar | 12. Oldman (Tr. 14-4) |
| 6. Dennison | 13. Mountain Park. |
| 7. Greennill | |

FIGURE III.

Area	Township	Coal	Ratio	Vol.	C/H	R.T.U.	R.T.U.	Moisture	Inert	Fixed C.	Fixed C.	Carbon
Belly River Horizon.	Edmonton	70-11	1.42	2.88	11.8	12.2	12,230	14,220	12.9	15.8	3.6	50.5
		70-10	1.46	2.90			12,000	14,280	14.2		3.1	49.9
		70-9	1.47	2.81			11,900	14,190	13.7		3.1	49.9
		48-22	1.50	2.67			12,340	13,690	8.8		5.2	51.0
	Edmonton	49-21	1.51	2.51			11,920	13,560	10.8		4.1	49.9
		47-20	1.46	2.70			12,420	13,790	8.0		5.4	53.4
		47-19	1.45	2.64	12.4	12.9	11,920	13,810	11.8	15.7	3.7	51.1
		40-15	1.50	2.80	12.9	13.5	12,030	13,420	9.6	14.5	5.2	53.8
	Pekisko	40-12	1.58	3.21	12.6	13.4	12,300	13,850	6.6	11.2	5.3	54.4
		40-3	1.58	3.19			13,770	14,840	5.7		7.5	53.8
Edmonton	Edmonton	18-2	1.50	2.91	12.0	13.2	13,360	14,900	7.9	12.5	8.9	51.6
		22-3	1.58	3.10			13,580	14,650	6.7		5.8	53.7
		20-2	1.54	3.04			13,450	14,790	8.0		7.4	52.2
		7-2	1.52	3.02	11.7	12.7	13,750	14,970	6.8	11.5	5.8	52.3
	Edmonton	8-2	1.52	2.85	12.5	13.2	13,440	14,550	6.5	11.6	6.9	52.6
		10-2	1.42	3.31			13,580	14,880	6.9		6.2	53.6
		4-28	1.14	2.55			13,390	14,680	7.3		5.5	48.5
		1-26	1.53	2.87	15.5	14.1	13,280	14,420	7.0	13.8	6.6	52.5
	Lethbridge	2-26	1.40	3.01	12.5	13.0	13,250	14,520	7.4	13.4	6.1	53.3
		8-22	1.29	2.46			12,250	14,000	11.1		3.9	49.3
Milk River	Milk River	3-16	1.45	2.25	11.4	11.7	12,310	13,850	9.9	18.3	4.5	50.4
		2-15	1.48	2.25	10.7	11.4	11,540	13,770	10.4	15.2	4.0	48.2
		3-11	1.40	1.90			10,300	13,280	20.1		4.6	50.2
		2-0	1.33	1.67			9,620	12,930	22.5		4.1	50.0
	Pekowki	8-8	1.32	1.79			9,320	12,700	24.7		3.6	48.8
		9-5	1.12	1.49			7,710	11,820	31.0		2.2	46.1
		8-4	1.04	1.43			7,640	11,790	32.9		1.7	42.9
		8-3	0.95	1.38			6,750	11,600	37.5		1.9	44.8
	Tabor	7-2	1.07	1.49			7,640	12,000	33.0		1.6	41.8
		10-17	1.34	2.08	10.5	10.6	11,250	13,450	14.9	18.8	1.9	45.0
Edmonton Horizon.	Edmonton	53-7	1.63	2.10	9.9	11.5	10,180	13,020	19.1	18.3	2.2	48.6
		53-4	1.52	2.18	9.1	10.1	9,530	12,550	21.9	20.4	1.9	45.8
		51-25	1.45	1.86			9,730	13,020	23.4		1.7	44.2
		53-24	1.46	1.81	8.4	10.6	9,470	12,840	24.9	21.9	1.6	43.6
	Edmonton	55-25	1.36	1.94	8.3	9.3	9,270	12,800	25.4	23.4	1.5	41.7
		55-24	1.37	1.70	8.4	9.2	9,160	12,710	25.6	21.3	1.5	41.7
		53-23	1.41	1.84	8.4	9.8	9,300	12,800	25.4	21.5	1.6	42.5
		50-19	1.36	1.71			8,970	12,700	27.7		1.4	40.7
	Tofield	49-18	1.32	1.77			8,760	12,680	28.5		1.3	39.3
		46-20	1.30	1.80	8.2	10.1	9,370	12,840	25.6	18.9	1.5	41.8
Edmonton	Edmonton	48-20	1.29	1.57			9,020	12,530	27.2		1.4	40.1
		48-19	1.27	1.61			8,480	12,530	26.9		1.4	40.1
		48-12	1.35	1.89			9,020	12,650			1.4	40.9
		43-20	1.31	2.03			9,540	12,850	23.4		1.6	42.2
	Castor	41-18	1.37	1.72			9,550	12,700	24.8		1.8	43.5
		42-18	1.34	1.69			9,250	12,620	25.4		1.6	42.0
		41-17	1.32	1.64			9,480	12,920	24.8		1.6	41.7
		39-16	1.36	1.75			9,190	12,620	25.8		1.5	42.0
	Ardley	42-17	1.34	1.60			9,220	12,950	25.6		1.4	40.7
		40-16	1.32	1.95	8.2	8.9	9,270	12,870	25.5	22.7	1.5	41.0
Edmonton	Edmonton	43-17	1.34	1.54			9,250	12,990	26.6		1.4	40.7
		41-16	1.38	2.01			9,160	12,630	26.4		1.5	42.0
		39-15	1.29	1.71	7.9	8.5	8,620	12,410	27.4	23.5	1.3	39.1
		37-14	1.23	1.63	7.5	8.6	8,360	12,260	29.3	24.9	1.2	37.7
	Ardley	40-15	1.32	2.05			9,220	12,770	25.7		1.5	41.0
		38-14	1.22	1.75	9.9	10.3	8,400	12,210	29.3	20.8	1.2	37.8
		32-23	1.56	2.09			9,980	12,830	20.1		2.1	47.4
		37-22	1.41	1.82			10,050	12,070	19.4		2.0	45.1
	Big Valley	33-22	1.40	1.80			10,250	13,100	20.2		2.1	45.7
		34-22	1.64	2.14			10,170	12,960	18.8		2.2	48.4
Edmonton	Edmonton	74-21	1.50	2.17			9,940	12,990	19.8		2.0	46.2
		76-20	1.41	1.94			9,500	12,710	21.7		1.8	44.0
		27-23	1.45	2.04			10,640	12,940	15.2		2.7	48.5
		31-24	1.66	2.22	10.7	11.2	10,750	13,270	17.1	19.6	2.7	50.6
	Castor	29-23	1.44	2.11			10,880	13,320	16.5		2.6	48.3
		31-23	1.60	2.12	10.6	11.2	10,500	13,170	17.8	19.5	2.5	49.7
		31-22	1.51	2.12			10,450	13,350	18.2		2.3	47.4
		41-21	1.55	2.07			10,460	13,080	18.9		2.4	45.7
	Castor	22-21	1.44	1.94			10,100	12,880	18.9		2.4	45.7
		41-16	1.38	2.01			9,160	12,630	26.4		1.5	42.0

Ardley	36-14	1.22	1.75	9.9	10.3	8,400	12,210	29.3	20.8	1.2	37.8	60.2
	38-23	1.50	2.09			9,980	12,830	20.1		2.1	47.4	
	37-22	1.41	1.82			10,050	12,070	19.4		2.0	45.1	
	38-22	1.40	1.80			10,250	13,100	20.2		2.1	45.7	
Big Valley	34-22	1.64	2.14			10,170	12,960	18.8		2.2	48.4	
	34-21	1.50	2.17			9,990	12,990	19.8		2.0	46.2	
	35-20	1.41	1.98			9,500	12,710	21.7		1.8	44.0	
	27-23	1.43	2.06			10,640	12,940	15.2		2.7	48.5	
Carbon	31-24	1.60	2.22	10.7	11.2	10,750	13,270	17.1	19.6	2.7	50.6	63.5
	29-23	1.45	2.11			10,880	13,320	16.5		2.6	48.3	
	33-23	1.66	2.22	10.6	11.2	10,500	13,170	17.8	19.5	2.5	49.7	63.0
	31-22	1.51	2.12			10,550	13,350	18.2		2.3	47.4	
Drumeller	31-21	1.55	2.07			10,460	13,080	18.9		2.4	48.7	
	32-21	1.59	1.94			10,140	12,920	19.6		2.1	45.7	
	28-20	1.37	1.95			10,610	13,230	18.0		2.4	46.5	
	29-20	1.41	2.15	10.0	11.1	10,550	13,170	18.6	20.3	2.3	46.7	62.4
#1 seam	28-19	1.37	2.02	9.9	11.6	10,410	13,060	18.7	19.7	2.3	46.1	62.5
	27-18	1.44	1.94	9.5	10.6	9,960	12,920	20.8	21.0	2.1	45.4	59.4
	29-19	1.46	2.05			10,300	13,050	19.6		2.2	46.9	
	29-20	1.44	2.04	10.4	11.7	10,180	13,050	20.5	19.5	2.1	46.1	61.4
#5 seam	28-19	1.49	2.02			10,130	12,900	19.6		2.2	47.0	
	29-20	1.49	1.99			10,390	13,050	18.6		2.3	47.7	
Gleichen	30-17	1.34	1.84			10,480	13,180	16.8		2.2	45.5	
	33-16	1.46	1.70			9,180	12,650	24.7		1.6	43.1	
	29-14	1.29	1.86			8,310	12,180	29.4		1.2	38.4	
	28-13	1.33	1.90	8.3	8.9	9,440	12,920	24.2	23.3	1.6	41.7	55.2
Sneerness	34-14	1.32	1.91			8,960	12,670	25.9		1.4	40.2	
	29-12	1.34	1.84			8,440	12,330	29.2		1.2	38.8	
	33-13	1.28	1.80			8,900	12,590	27.3		1.4	40.5	
	14-23	1.23	1.77			8,670	12,390	27.7		1.3	39.3	
Cnamion	15-23	1.26	2.31			11,700	13,490	12.1		3.7	49.3	
	16-23	1.29	2.23	11.0	11.7	11,330	13,200	13.1	20.4	3.4	48.0	67.0
	14-22	1.50	2.35			11,520	13,380	12.6		3.5	48.4	
	15-22	1.57	2.18			11,250	13,240	14.0		3.4	51.0	
16-21	15-21	1.30	2.07			11,170	13,300	15.0		3.0	48.5	
	16-21	1.36	1.93			11,050	13,220	15.3		2.8	47.0	
						10,800	13,350	17.4		2.4	46.0	

Area and Township No.	Miles from Division	B.T.U. as mined	B.T.U. Dry	Heat Ratio	Moisture A.M. unadjusted	F.C. Moisture as mined	Fixed Carbon A.M.	C/H as mined	C/H air dry	Inert Volatile	Carbon as coal
Pekisko (20-3)	29	13,490	14,900	1.38	5.7	8.9	53.8	12.6	13.4	11.2	79.6
" (22-4)	31	13,770	14,840	1.38	6.6	7.9	54.4	11.7	12.7	11.5	78.3
Pincher (7-2)	18	13,750	14,970	1.32	6.8	6.4	52.3				
" (10-2)	17	13,580	14,880	1.42	6.9	6.2	53.6				
Pekisko (22-3)	32	13,580	14,650	1.38	6.7	7.4	53.7				
" (20-2)	33	13,450	14,790	1.34	8.0	5.8	52.2	12.5	13.2	11.6	78.9
Pincher (8-2)	20	13,440	14,550	1.32	6.5	6.9	52.6				
McGroth (4-26)	24	13,340	14,680	1.14	7.3	5.5	48.5				
Pekisko (18-2)	29	13,360	14,670	1.30	7.9	5.8	51.6	12.0	13.2	12.5	77.2
McGroth (1-26)	29	13,280	14,420	1.33	7.0	6.6	52.5	13.3	14.1	13.8	77.7
" (2-26)	30	13,250	14,520	1.40	7.4	6.1	53.3	12.5	12.5	13.0	76.5
Coalspur (47-20)	68	12,420	13,740	1.46	8.0	6.4	53.4				
Saunders (40-12)	72	12,390	13,850			5.3	48.2	12.6	13.4	14.5	72.9
Lethbridge (7-21)	67	12,360	14,090	2.41	10.4	4.0	51.0	11.2	11.9	15.2	72.1
Coalspur (48-22)	63	12,340	13,690	2.67	8.8	5.2	50.4				
Lethbridge (9-22)	72	12,310	13,850	2.46	9.9	4.5	49.3	11.4	11.7	18.3	71.5
" (8-22)	69	12,250	14,000	2.46	11.1	3.9	50.5	11.8	12.2	15.8	71.1
Falcourt (70-11)	-	12,230	14,220	2.88	12.9	4.1	50.0	11.2	11.6	15.2	72.2
Lethbridge (9-21)	70	12,210	13,870	1.32	10.9	4.6	50.2	11.6	12.0	17.2	71.7
" (10-22)	77	12,160	13,650	1.33	10.0	5.2	53.8				
Saunders (40-13)	68	12,030	13,420	1.50	9.6	3.1	49.9				
Falcourt (70-10)	-	12,020	14,280	2.90	14.2	3.7	49.3	12.4	12.9	15.7	70.4
Coalspur (47-19)	72	11,920	13,810	2.64	11.8	3.7	51.1				
" (49-21)	72	11,920	13,560	2.51	10.8	4.1	49.9				
Falcourt (70-7)	-	11,900	14,140	2.81	13.7	3.1	49.9	10.9	11.7	17.2	67.0
Lethbridge (10-21)	80	11,810	13,660	1.29	12.1	3.6	48.8				
Campanion (14-24)	74	11,700	13,490	2.31	12.1	3.7	49.3				
Milk River (2-16)	88	11,680	13,820	1.49	13.4	3.3	50.5	10.7	11.4	16.3	69.1
" (2-14)	91	11,540	13,770	1.48	14.3	3.1	49.9	11.0	11.7	20.4	67.0
Campanion (10-24)	77	11,520	13,380	1.29	12.6	3.5	48.4				
Milk River (3-10)	89	11,500	13,650	2.25	13.4	3.2	49.9				
Campanion (15-23)	73	11,350	13,200	2.24	13.1	3.4	48.0	10.6	11.1	18.0	66.1
Taber (9-16)	103	11,270	13,670	2.18	14.9	2.9	48.9	10.5	10.6	18.8	64.6
" (10-17)	100	11,260	13,550	2.08	14.9	2.8	47.5				
Campanion (14-22)	83	11,250	13,240	2.35	14.0	3.4	51.0				
" (15-22)	82	11,170	13,300	2.18	15.0	3.0	48.5				
" (15-21)	87	11,050	13,220	2.07	15.3	2.8	47.0				
Carbon (29-23)	106	10,880	13,320	2.11	16.5	2.6	48.3	10.1	10.5	18.0	65.8
Taber (10-16)	108	10,880	12,980		15.0			10.7	11.2	19.6	63.5
Campanion (10-21)	83	10,800	13,350	1.93	17.4	2.4	46.0				
Carbon (31-24)	112	10,750	13,270	2.22	17.1	2.7	50.6				
Brooks (17-17)	109	10,640	13,310	1.92	17.9	2.3	46.4				
Carbon (27-23)	104	10,640	12,940	2.05	15.2	2.7	48.5				
Drumeller (128-20)	119	10,610	13,230	1.95	18.0	2.4	46.5				
Carbon (31-22)	119	10,550	13,350	2.12	18.2	2.3	47.4				
Drumeller (129-20)	121	10,550	13,170	2.15	18.6	2.3	46.7	10.0	11.1	20.3	62.4
Taber (9-13)	129	10,500	13,230	1.95	18.5	2.2	46.1				
Carbon (33-23)	120	10,500	13,170	2.22	17.8	2.5	49.7	10.6	11.2	19.5	63.0
Gleichen (25-22)	98	10,480	13,180	1.84	16.8	2.2	45.5				
Carbon (31-21)	118	10,460	13,080	2.07	18.9	2.4	48.7				
Drumeller (128-19)	121	10,410	13,060	2.02	18.7	2.3	46.1	9.9	11.6	19.7	62.5
" (29-20)	121	10,390	13,050	1.99	18.6	2.3	47.7				
Milk River (3-11)	117	10,300	13,280	1.90	20.1	2.1	46.0				
Drumeller (229-19)	122	10,300	13,050	2.05	19.6	2.2	46.9				
Arday (38-22)	148	10,250	13,100	1.80	20.2	2.1	45.7				
Drumeller (29-20)	121	10,180	13,050	2.04	20.5	2.1	46.1	10.4	11.7	19.5	61.4
Pembine (33-7)	149	10,180	13,020	1.63	19.1	2.2	48.6	9.9	11.5	18.3	62.4
Big Valley (34-22)	138	10,170	12,960	1.64	18.8	2.2	48.4				
Carbon (32-21)	134	10,140	12,920	1.59	19.6	2.1	45.7				
Drumeller (528-19)	124	10,130	12,900	2.02	19.6	2.2	47.0				
Arday (37-22)	145	10,050	13,070	1.82	19.4	2.0	45.1				
Big Valley (34-21)	132	9,990	12,990	2.17	19.8	2.0	46.2				
Arday (38-23)	142	9,980	12,830	2.09	20.1	2.1	47.4	9.9	10.3	20.8	60.2
Drumeller (127-18)	124	9,960	12,920	1.94	20.8	2.1	45.4	9.5	10.6	21.0	59.4
Taber (11-11)	141	9,890	13,020	1.87	22.3	1.9	44.8				
" (8-10)	133	9,830	13,090	1.79	21.7	1.7	42.9				
" (12-10)	147	9,830	12,960	1.87	22.2	1.9	45.0				
Edmonton (21-23)	178	9,730	13,020	1.86	23.4	1.7	44.2				
Taber (7-9)	138	9,680	12,960	1.70	22.9	1.6	41.8				
Parkowki (2-6)	147	9,620	12,930	1.67	22.5	1.7	42.4				
Big Valley (35-20)	150	9,560	12,716	1.98	21.7	1.8	44.0				
Castor (41-13)	178	9,550	12,700	1.72	24.8	1.8	43.5				
" (43-20)	178	9,540	12,850	2.08	23.4	1.6	42.2				
Pembina (53-4)	165	9,530	12,550	2.18	21.9	1.9	45.8	9.1	10.1	20.4	57.7
Castor (41-17)	183	9,480	12,920	1.64	24.8	1.6	41.7	8.4	10.6	21.9	56.3
Edmonton (53-24)	194	9,470	12,880	1.81	24.9	1.6	43.6	8.3	8.9	23.3	55.2
Sheerness (29-14)	152	9,440	12,920	1.90	23.3	1.6	41.7				
Camrose (40-20)	135	9,370	12,830	1.36	25.0	1.5	41.8	8.2	10.1	18.9	50.2
Parkowki (3-3)	144	9,320	12,700	1.79	24.7	1.6	41.8				
Edmonton (53-23)	194	9,300	12,800	1.84	25.4	1.6	42.5	8.4	9.8	21.5	55.8
Castor (40-16)	185	9,270	12,870	1.95	25.5	1.5	41.0	8.2	8.9	22.7	54.5
Edmonton (55-25)	192	9,270	12,800	1.94	26.4	1.5	40.7	8.3	9.3	23.4	54.3
Castor (43-17)	185	9,250	12,990	1.34	26.6	1.4	40.7				
" (42-12)	178	9,250	12,620	1.34	25.4	1.6	42.0				
" (42-17)	184	9,220	12,950	1.34	25.6	1.4	40.7				
" (40-15)	190	9,220	12,770	2.05	25.7	1.5	41.0				
" (39-16)	182	9,140	12,620	1.75	25.8	1.5	42.0	8.1	9.6		55.3
Sheerness (70-17)	145	9,180	12,650	1.46	24.7	1.6	43.1				
Edmonton (55-24)	200	9,160	12,710	1.37	25.6	1.5	41.7	8.4	9.2	21.3	55.4
Castor (41-16)	184	9,160	12,630	1.38	26.4	1.5	42.0				

Camrose (40-20)	185	9,370	12,880	1.30	1.80	25.0	1.5	41.8	822	10.1	18.9	56.2
Peikowki (8-8)	144	9,320	12,700	1.32	1.79	24.7	1.6	41.8				
Edmonton (53-23)	194	9,300	12,800	1.41	1.84	25.4	1.6	42.5	8.4	9.8	21.5	55.8
Castor (40-16)	185	9,270	12,870	1.32	1.95	25.5	1.5	41.0	8.2	8.9	22.7	54.5
Edmonton (55-25)	192	9,270	12,800	1.36	1.94	25.4	1.5	41.7	8.3	9.3	23.4	54.3
Castor (43-17)	185	9,250	12,990	1.34	1.54	26.6	1.4	40.7				
" (42-18)	178	9,250	12,620	1.34	1.69	25.4	1.6	42.0				
" (42-17)	184	9,220	12,950	1.34	1.60	25.6	1.4	40.7				
" (40-15)	190	9,220	12,770	1.32	2.05	25.7	1.5	41.0	8.1	9.6		55.3
" (39-16)	182	9,190	12,620	1.36	1.75	25.8	1.5	42.0				
Sheerness (30-17)	145	9,180	12,650	1.46	1.70	24.7	1.6	43.1				
Edmonton (55-24)	200	9,160	12,710	1.37	1.70	25.6	1.5	41.7	8.4	9.2	21.3	55.4
Castor (41-16)	189	9,160	12,630	1.38	2.01	26.4	1.5	42.0				
Redcliff (13-6)	164	9,070	12,680	1.44	2.11	26.2	1.5	42.2				
Camrose (42-18)	201	9,020	12,650	1.35	1.89	27.1	1.4	40.9				
" (48-20)	200	9,020	12,530	1.29	1.57	27.2	1.4	40.1				
" (50-19)	196	8,980	12,530	1.27	1.61	26.9	1.4	40.1				
Toriold (50-19)	205	8,970	12,700	1.36	1.71	27.7	1.4	40.7				
Sheerness (28-13)	162	8,960	12,670	1.32	1.91	25.9	1.4	40.2				
" (29-12)	162	8,900	12,590	1.34	1.80	27.3	1.4	40.5				
Toriold (49-18)	206	8,760	12,680	1.32	1.77	28.5	1.3	39.3				
Sexsmith (75-3)	-	8,690	12,720	1.35	2.05	29.6	1.2	39.2				
Sheerness (33-13)	173	8,670	12,390	1.28	1.77	27.7	1.3	39.3	7.9	8.5	23.5	52.2
Castor (39-15)	181	8,620	12,410	1.29	1.71	27.4	1.3	39.1				
Sheerness (34-14)	172	8,440	12,330	1.31	1.84	29.2	1.2	38.8				
Castor (38-14)	186	8,400	12,210	1.22	1.75	29.3	1.2	37.8	7.5	8.6	24.9	50.4
" (37-14)	185	8,360	12,260	1.23	1.68	29.3	1.2	37.7				
Sheerness (33-16)	156	8,310	12,180	1.29	1.86	29.4	1.2	38.4				
Peikowki (9-5)	166	7,710	11,820	1.12	1.49	31.0	1.0	34.5				
" (7-2)	177	7,640	12,000	1.07	1.49	33.0	0.9	32.9				
" (8-4)	168	7,540	11,790	1.04	1.43	32.9	0.9	32.6				
" (803)	174	6,750	11,600	0.95	1.38	37.5	0.7	28.3				

TABLE I X.

Table showing the Order Into Which Coals of the Belly River and Edmonton Horizons fall when arranged by the Criteria mentioned at the head of each column.

Area and Township No.	From Division	R.T.U. moist coal	B.I.U. dry coal	Mats. as mined	Fixed Carbon mois. coal	P.C. mois. as mined	Split Vol. ratio	Fuel Ratio	Carbon moist coal	C/H moist coal	Isolation temperature	Ultimate content
Pekisko (20-3)	5th	1st	2nd	1st	2nd	1st	3rd	42nd	1st	2nd	1st	1st
" (22-4)	9	2	4	2	1	2	2	42	3	9		
Pincher (7-2)	2	3	1	5	10	6	5	71				
" (10-2)	1	4	3	6	5	7	1	32				
Pekisko (20-3)	10	5	8	4	4	3	4	42				
" (20-2)	11	6	5	12	11	9	6	59	2	4		
Pincher (8-2)	3	7	9	2	8	4	12	71				
McArthur (4-28)	4	8	6	9	34	11	18	103	5	7		
Pekisko (18-2)	5	9	7	11	12	9	8	86	4	1		
McArthur (1-26)	6	10	11	7	9	5	11	66	6	4		
" (2-26)	8	11	10	10	7	8	7	39				
Coalspur (47-20)	14	12	22	12	6	12	15	18	7	2		
Saunders (40-12)	17	13	18	17	40	20	23	101	9	12		
Letnbridge (7-21)	15	14	15	14	14	14	16	86				
Coalspur (48-22)	12	15	24	16	19	17	21	81	11	11		
Letnbridge (9-22)	17	16	18	21	28	24	10	89	12	8		
" (5-22)	16	17	16	26	17	18	20	71	8	12	2	
Holcourt (70-11)	23	18	13	20	21	18	20	32	10	10		
Letnbridge (9-21)	24	19	17	20	20	16	23	66				
" (10-22)	21	20	32	15	2	14	14	9				
Saunders (40-13)	14	21	32	31	22	31	9	18	13	6		
Holcourt (70-10)	17	22	12	22	13	22	17	23				
Coalspur (47-19)	17	23	21	22	22	22	14	81	14	15	5	
" (49-21)	17	24	29	19	22	31	13	16				
Holcourt (70-7)	25	25	14	30	22	31	25	89				
Letnbridge (10-21)	26	26	26	23	31	24	27	95				
Champion (14-23)	22	27	31	23	28	22	27	12				
Milk River (2-16)	31	28	20	28	17	29	28					
Milk River (2-15)	33	29	23	31	22	31	29	15	15	16	3	
Champion (10-23)	24	30	33	25	37	26	32	89	16	14		
Milk River (3-16)	32	31	27	28	41	30	29	23				
Champion (15-23)	21	32	45	33	41	35	31	99	17	18	4	
Taber (9-16)	36	33	25	33	43	36	35	34	19	20		
" (10-17)	35	34	30	33	43	36	40	59				
Champion (14-22)	28	35	41	31	14	27	26	9				
" (15-22)	27	36	38	35	34	34	35	47				
" (16-21)	30	37	44	38	47	36	48	86				
Caroon (29-23)	38	38	44	38	47	36	42	23				
Taber (10-16)	39	39	36	39	39	41	42		18	22		
Champion (10-21)	28	40	62	35	56	43	60	52				
Caroon (31-24)	41	41	40	41	16	39	33	1	20	16	10	6
Brooks (17-17)	40	42	37	44	61	46	69	81				
Caroon (27-23)	37	43	67	37	34	39	50	30				
(1)D'neller (28-20)	44	44	42	45	50	43	60	47				
Caroon (31-22)	44	45	34	46	43	46	41	8	23	23	9	5
1)D'neller (29-20)	46	46	47	48	49	50	60	42				
Taber (9-13)	54	47	47	47	52	47	33	1	21	18		
Caroon (33-23)	53	48	47	43	27	42	76	59				
Gleichen (25-22)	34	49	46	50	60	50	48	6	24	24	11	8
Caroon (31-21)	43	50	51	52	32	43	55	47				
1)D'neller (28-19)	40	51	53	50	52	46	55	12				
7) " (29-20)	46	52	54	48	41	46	48	18				
Milk River (3-11)	42	53	39	59	55	56	69	39				
2)D'neller (29-19)	50	54	54	55	48	50	50	27				
Ardley (38-22)	67	55	49	61	58	56	81	27	25	21	14	10
5)D'neller (29-20)	49	56	54	62	52	56	54	4	23	24	8	9
Pembina	68	57	57	53	33	50	44	3				
Big Valley (34-22)	58	58	64	51	37	50	40	3				
Caroon (32-21)	57	59	69	55	58	56	63	41				
5)D'neller (28-14)	51	60	73	55	46	50	55	12				
Ardley (27-22)	63	61	52	64	63	62	79	34				
Big Valley (34-21)	55	62	60	58	51	62	38	9				
Ardley (38-23)	61	63	78	59	43	56	45	5	24	27	12	12
1)D'neller (27-18)	51	64	69	63	61	56	63	27	26	27		
Taber (11-11)	60	65	57	68	64	64	72	30				
" (8-10)	56	66	50	64	71	69	84	66				
" (12-10)	65	67	62	67	64	64	72	16				
Edmonton (51-25)	82	68	57	69	66	69	74	23				
Taber (7-9)	58	69	64	71	79	72	93	95				
Parkowki (2-6)	65	70	68	70	73	69	98	66				
Big Valley (35-20)	69	71	82	64	67	67	59	34				
Castor (41-18)	82	72	85	75	69	67	90	47				
" (47-20)	82	73	77	73	74	72	46	81	28	28		
Pembina (35-4)	75	74	97	66	57	64	35	7				
Castor (41-17)	88	75	69	75	82	72	99	71	29	29	7	11
Edmonton (35-24)	98	76	74	77	68	72	80	18	32	32		
Sneeress (29-14)	70	77	64	72	82	72	69	66	34	34	13	14
Carrose (46-20)	90	78	74	82	79	81	84	52				
Parkowki (2-8)	62	79	85	74	79	72	76	71	29	29	6	13
Edmonton (53-23)	92	80	79	78	72	81	60	34				
Castor (40-16)	90	81	76	82	86	81	103	52	34	32		
Edmonton (55-25)	97	82	74	78	82	84	96	59				
Castor (43-17)	90	83	60	91	89	81	101	54				
Castor (42-12)	82	84	94	78	77	72	96	59				
Castor (42-17)	84	85	65	82	84	89	101	54				
Castor (40-15)	96	86	81	86	86	81	50	71				
Castor (39-16)	87	87	94	87	77	81	88	52	36	36		
Sneeress (30-17)	63	88	90	74	70	72	94	18				

C-estor (41-17)	88	75	69	75	82	72	99	71	29	29	7	11
Edmonton (43-24)	98	76	74	77	68	72	80	18	32	32		
Sheerness (29-14)	70	77	69	72	82	72	69	66	34	34	13	14
Camrose (40-20)	90	78	74	82	79	81	84	52				
Pakowki (8-8)	62	79	85	74	79	72	76	71	29	29	6	13
Edmonton (53-23)	98	80	79	78	72	72	60	34	34	34		
Castor (40-16)	90	81	76	82	86	81	63	52	32	32		
Edmonton (55-25)	97	82	79	78	82	81	103	59				
Castor (43-17)	90	83	60	91	89	89	96	59				
Castor (42-18)	82	84	94	78	77	72	101	59				
Castor (42-17)	89	85	65	82	89	89	50	59				
Castor (40-15)	96	86	81	86	86	81	88	71	36	36		
Castor (39-16)	87	87	94	87	77	81	93	52	33	33		
Sheerness (30-17)	63	88	90	74	70	72	93	18	29	29		
Edmonton (55-24)	101	89	82	82	82	81	93	47				
Castor (41-16)	94	90	93	90	76	81	57	42				
Redolif (13-6)	74	91	89	89	74	81	42	34				
Camrose (48-18)	103	92	90	93	88	89	71	57				
Camrose (48-20)	101	93	98	94	95	89	102	89				
Camrose (48-19)	100	94	98	92	95	89	100	98				
Tofield (50-19)	104	95	85	97	89	91	52					
Sheerness (28-13)	72	96	90	88	94	89	68	71				
Sheerness (29-12)	72	97	96	95	93	89	81	59				
Tofield (49-18)	105	98	85	97	89	89	86	71				
Sexsmith (75-3)		99	82	104	98	100	50	57				
Sheerness (32-13)	79	100	101	97	97	97	86	95	37	37		
Castor (39-15)	86	101	100	96	99	97	91	89				
Sheerness (34-14)	78	102	102	100	100	100	76	81				
Castor (28-14)	94	103	104	101	101	100	88	101	38	38		
Castor (37-14)	90	104	103	101	103	100	97	100				
Sheerness (33-16)	71	105	105	103	101	100	74	89				
Pakowki (4-5)	76	106	107	105	104	105	104	104				
Pakowki (7-2)	81	107	106	106	105	106	104	105				
Pakowki (8-4)	77	108	108	107	106	106	106	106				
Pakowki (8-3)	80	109	109	108	107	108	107	107				

F I G U R E I V. Sevler's Classification applied to Alberta
coals.

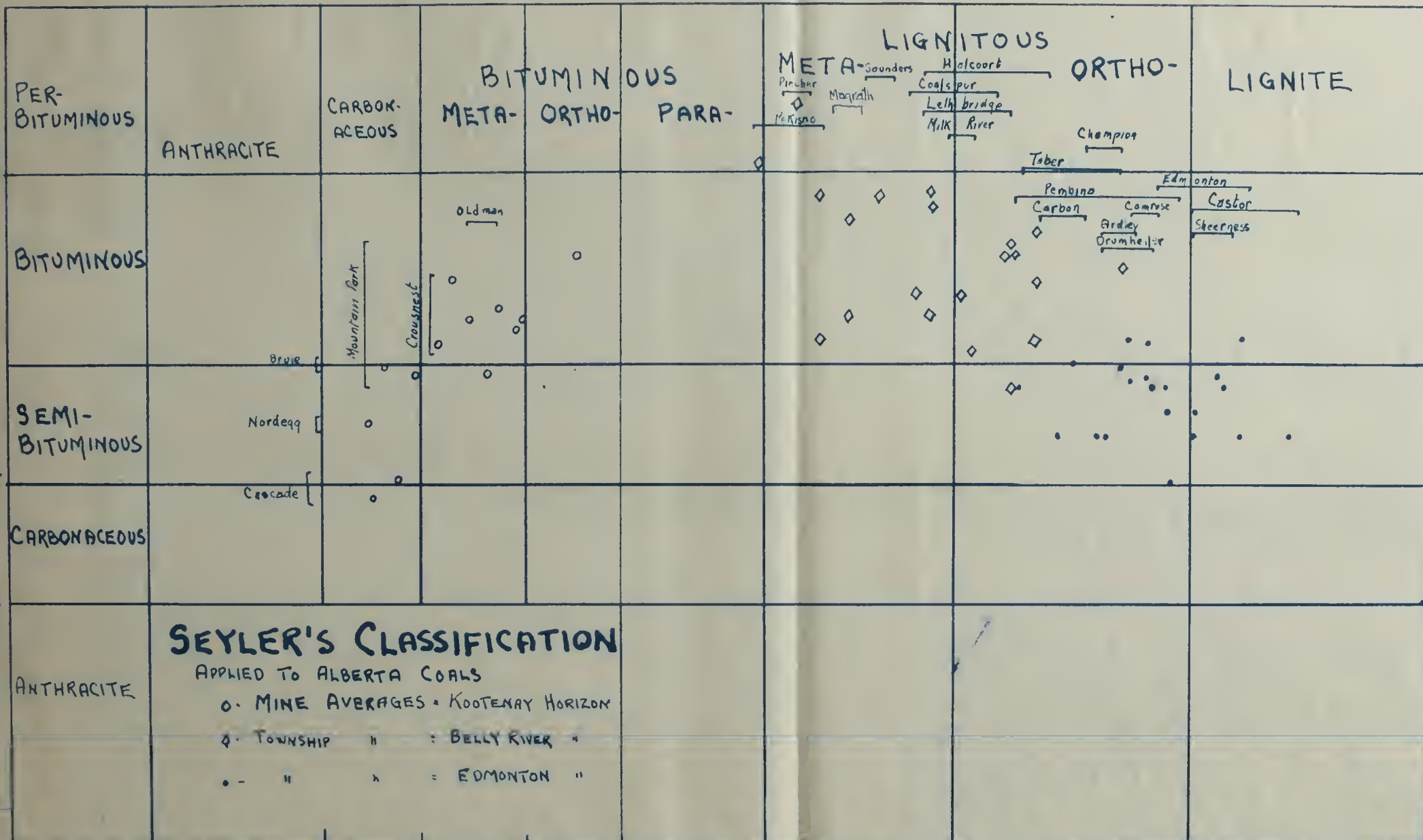
PERCENTAGE OF HYDROGEN

5.8

5

4.5

4



93.3 91.2 89 87 84 80 75

PERCENTAGE OF CARBON IN PURE COAL

TABLE X. SEYLER'S CLASSIFICATION.

Classes by Areas and Mines of the Kootenay Horizon and by Areas of the Belly River and Edmonton Horizons.

<u>Title of Class</u>	<u>Area and Mine or Township</u>
<u>Kootenay Horizon</u>	
Ortho-carbonaceous	Cascade (Canmore mine, Carey seam)
Ortho-semi-bituminous	Cascade (Canmore mine, Stewart seam)
	Brule
	Nordegg
	Mountain Park (Luscar)
Bituminous	
Meta -	Mountain Park (Cadomin)
	Crowsnest
Sub-meta -	Olaman
Ortho -	Mountain Park (Mountain Park)
<u>Belly River Horizon.</u>	
Per-para-	Pekisko ° (22-4)
Lignitous	
Meta	Halcourt
	Coalspur (47-19)
	Saunders
	Pekisko (18-2)
	Pincher (8-2)
	Magrath
	Lethbridge (70-9-21)
Per-meta-	Pincher (7-2)
Ortho-	Coalspur (48-22)
	Lethbridge* (3)
	Milk River
	Taber (3)
Sub-ortho -	Coalspur (48-21)
<u>Edmonton Horizon.</u>	
Ortho -	Camrose (46-20)
	Carbon (31-24)
	Ardley (38-23)
Sub-ortho -	Pembina
	Edmonton (3)
	Carbon (31-23)
	Big Valley (36-22)
	Drumheller (3)
	Champion (16-23)
Lignite	Edmonton (55-25)
	Castor
	Sheerness (29-14)

° Numbers of this sort in brackets refer to township numbers.

* Single numbers in brackets refer to the number of townships.

CALORIFIC VALUE OF PURE COAL B.T.U. /LB.

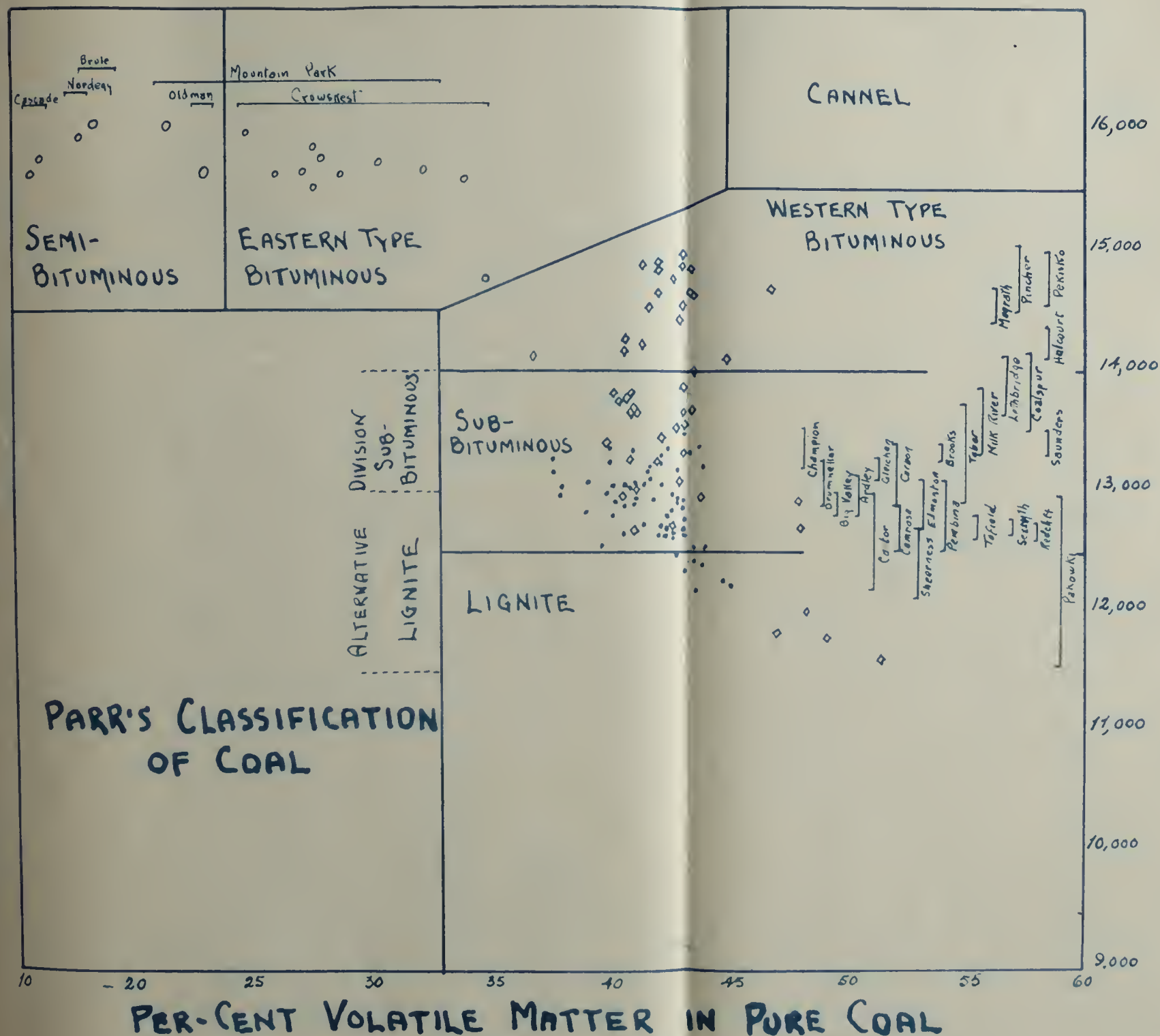
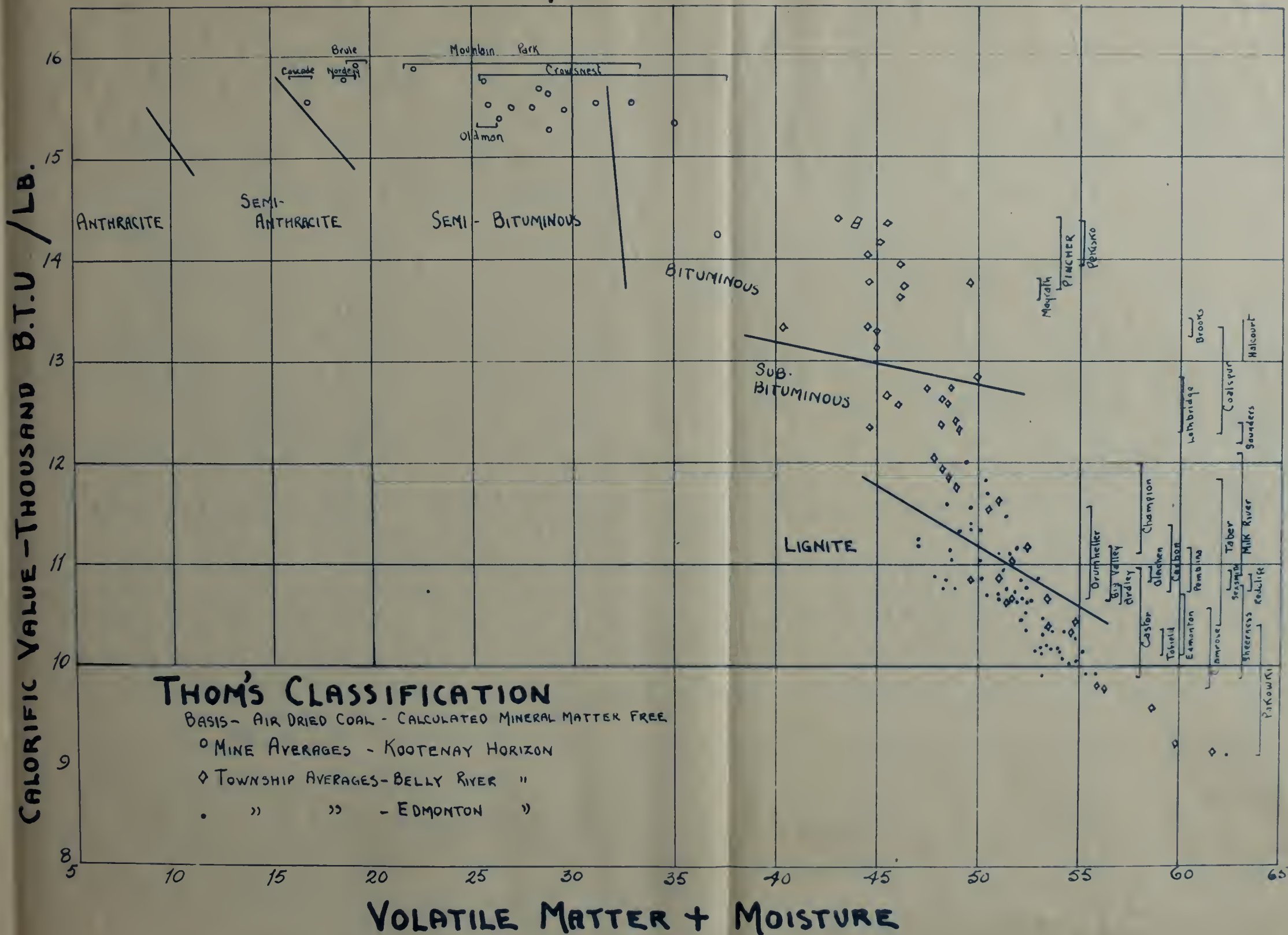


TABLE XI. Parr's Second Coal Classification - Applied to Alberta Coals.

Title of Class	Semi-bituminous	Eastern Type Bituminous	Western Type Bituminous	Sub-bituminous (Black Lignite)	Brown Lignite
Definition of class					
Calorific Value	15,500-16,000	15,000-16,000	14,000-15,000	13,000-14,000	11,500 -
Volatile Matter	14 to 24 %	24 to (33-47) %	Above (33-47) %	Above 33%	Above 33%
Areas by Classes:					
Kootenay horizon	Brule Mountain Park (1) Luscar Nordegg Crescoda Oldman	Mountain Park*(2) Crowsnest			
Belly River horizon			Welcourt Coalspur°(43-16) Pekisko Pincher Mcgrath Lethbridge(7-21)	Coalspur (4) Saunders Lethbridge (5) Milk River Taber (6) Brooks	Pekowki Redcliff Sexsmith Taber (2) (12-10 & 7-9)
Edmonton horizon				Pembina (53-7) Edmonton (51-25) Carbon (4) Drumheller #1 seam (3) #2 seam #5 seam #7 seam Gleichen Ardley	Pembina (53-4) Edmonton (4) Carbon (2) (32-21 & 27-23) Torfield Camrose Castor Ardley Big Valley Sneerness Drumheller #1 seam (27-18) #5 seam (28-19)

* Single numbers in brackets refer to the number of townships.

° Numbers of this sort in brackets refer to township numbers)



T A B L E X I I. Distribution by areas of the classes of Coal
as arranged by Thom's Classification.

T i t l e o f C l a s s			
Semi-bituminous	Bituminous	Sub-bituminous	Lignite
<u>Kootenay Horizon</u>			
Cascade	Mountain Park (1)		
Brule	Crowsnest (2)		
Crowsnest (3)	(6-2 & 5-1)		
Mountain Park (2)			
Oldman			
<u>Belly River horizon</u>			
	Helcourt	Coalsour	Milk River (1) (3-11)
	Pekisko	Lethbridge (5)	Pakowski
	Pincher	Milk River (3)	Sexsmith
	Magrath	Taber	
	Lethbridge (1)	Brooks	
	(7-21)		
<u>Edmonton Horizon</u>			
		Carbon (3)	Pembina
		Drumheller	Edmonton
		#1 seam (3)	Tofield
		Champion	Camrose
			Castor
			Ardley
			Big Valley
			Carbon (4)
			Drumheller
			#1 seam (27-18)
			#2 seam
			#5 seam
			#7 seam
			Sneerness

CALORIFIC VALUE - MOIST COAL - THOUSAND BTU/LB.

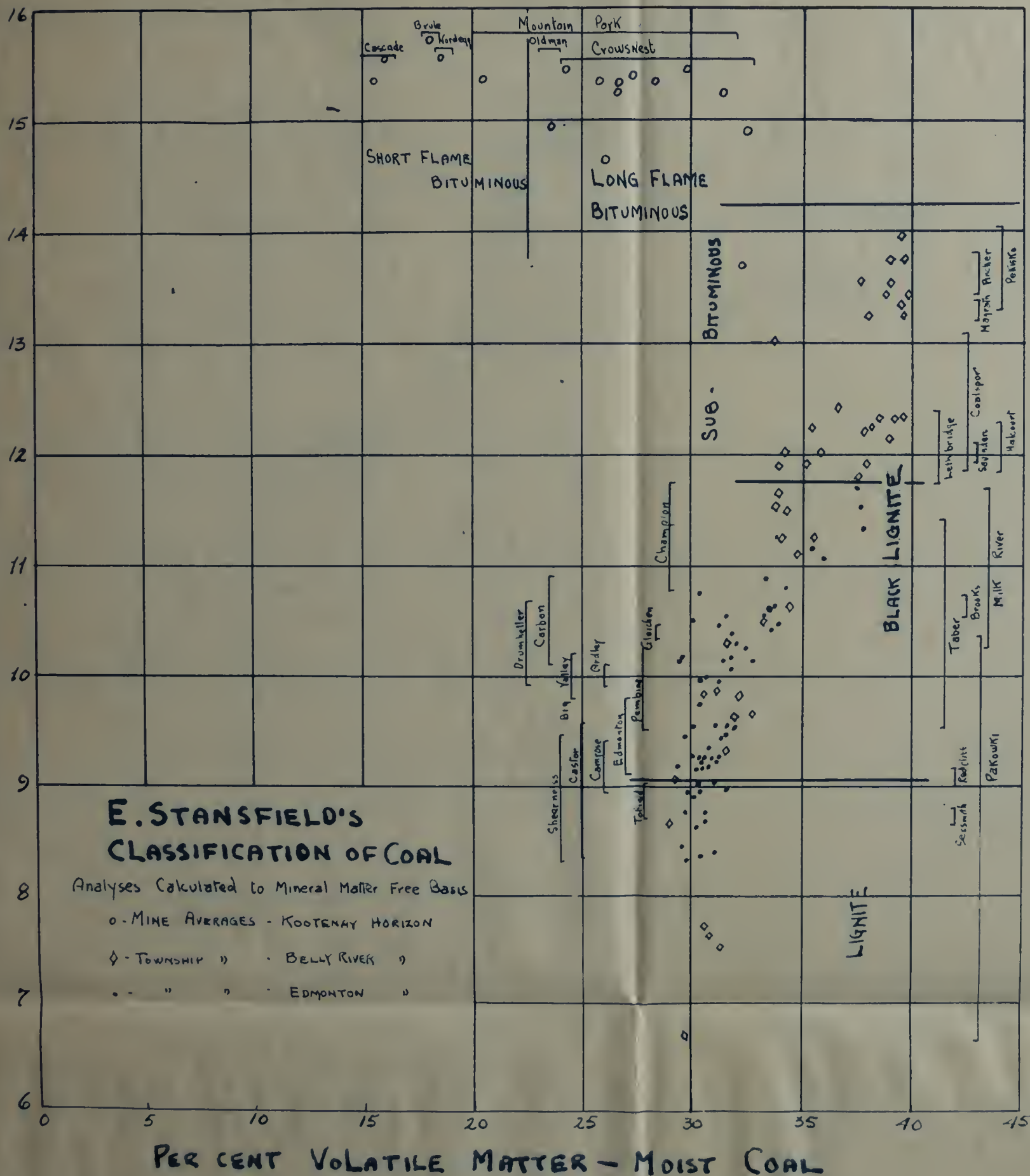
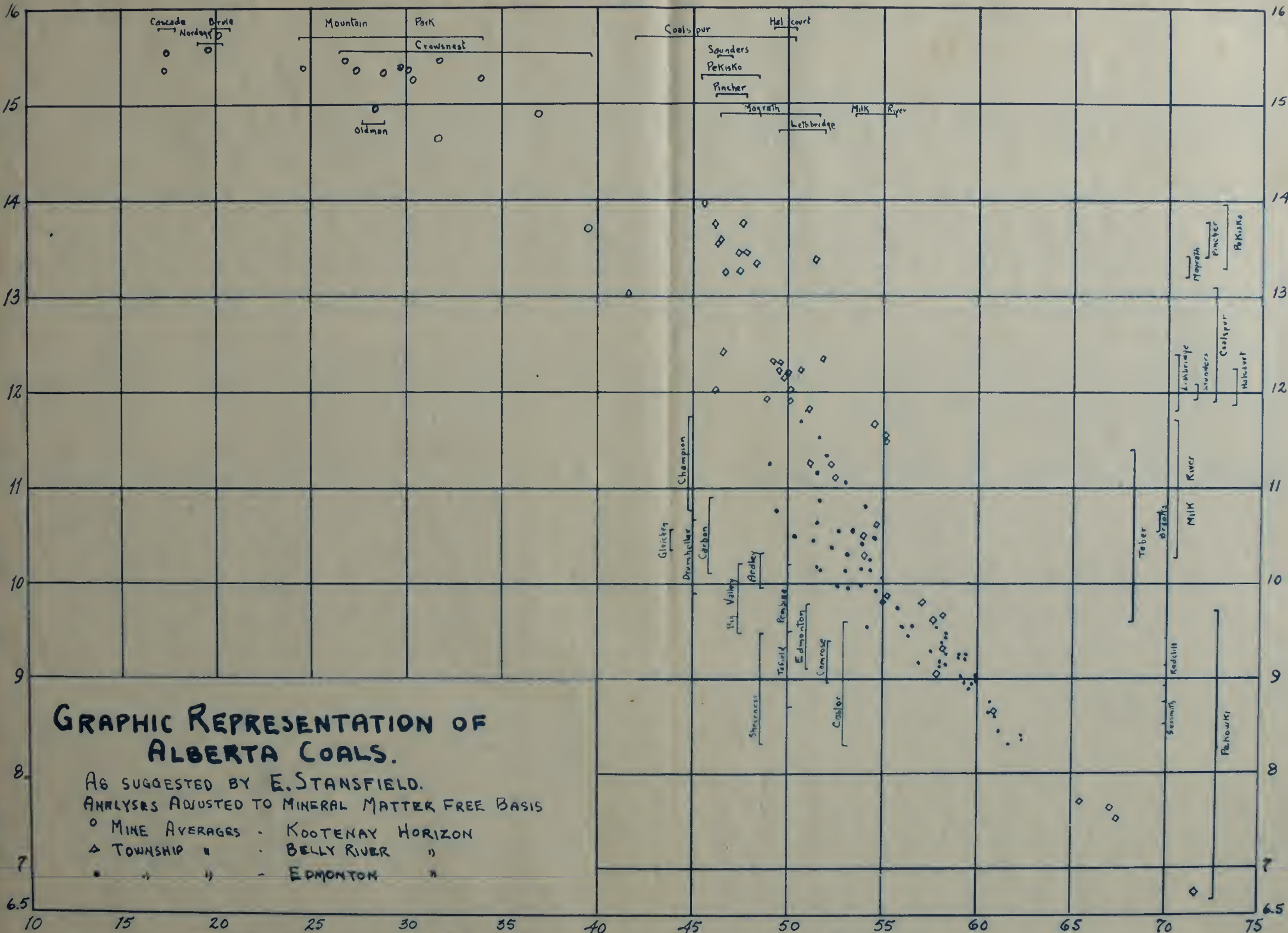


TABLE III. Alberta coals as Arranged by E. Spensfield's Classification.

Title of classes	Short Flame Bituminous	Long Flame Bituminous	Sub-bituminous	Black Lignite	Brown Lignite
Definition of class					
Colorific value	Above 14,250	Above 14,250	14,250 - 11,750	11,750 - 9,000	Below 9,000
Volatile Matter	Below 22.5%	Above 22.5%	-	-	-
<u>Areas by Classes</u>					
<u>Kootenay horizon</u>	Cascade Brule Nordegg Mountain Park (Luscar)	Mountain Park(2) Crowsnest Oldman			
<u>Belly River horizon</u>			Coalspur Helcourt Saunders Pekisko Pincher Macroth Lethbridge	Milk River Tober Brooke Redcliff Pekowki (2)	Pekowki (6) Sexsmith
<u>Edmonton horizon</u>				Pembina Edmonton Camrose (3) Castor (10) Ardley Rio Valley Carbon Dumellier Gleichen Sheerness (2)	Torfield Camrose (1)(48-19) Castor (3) Sheerness (5)

CALORIFIC VALUE OF MOIST COAL - THOUSAND B.T.U./LB.



PERCENTAGE OF VOLATILE MATTER + MOISTURE

PERCENTAGE MOISTURE IN MOIST COAL

50 40 30 20 10 0

PERCENTAGE VOLATILE MATTER IN MOIST COAL

40

30

20

10

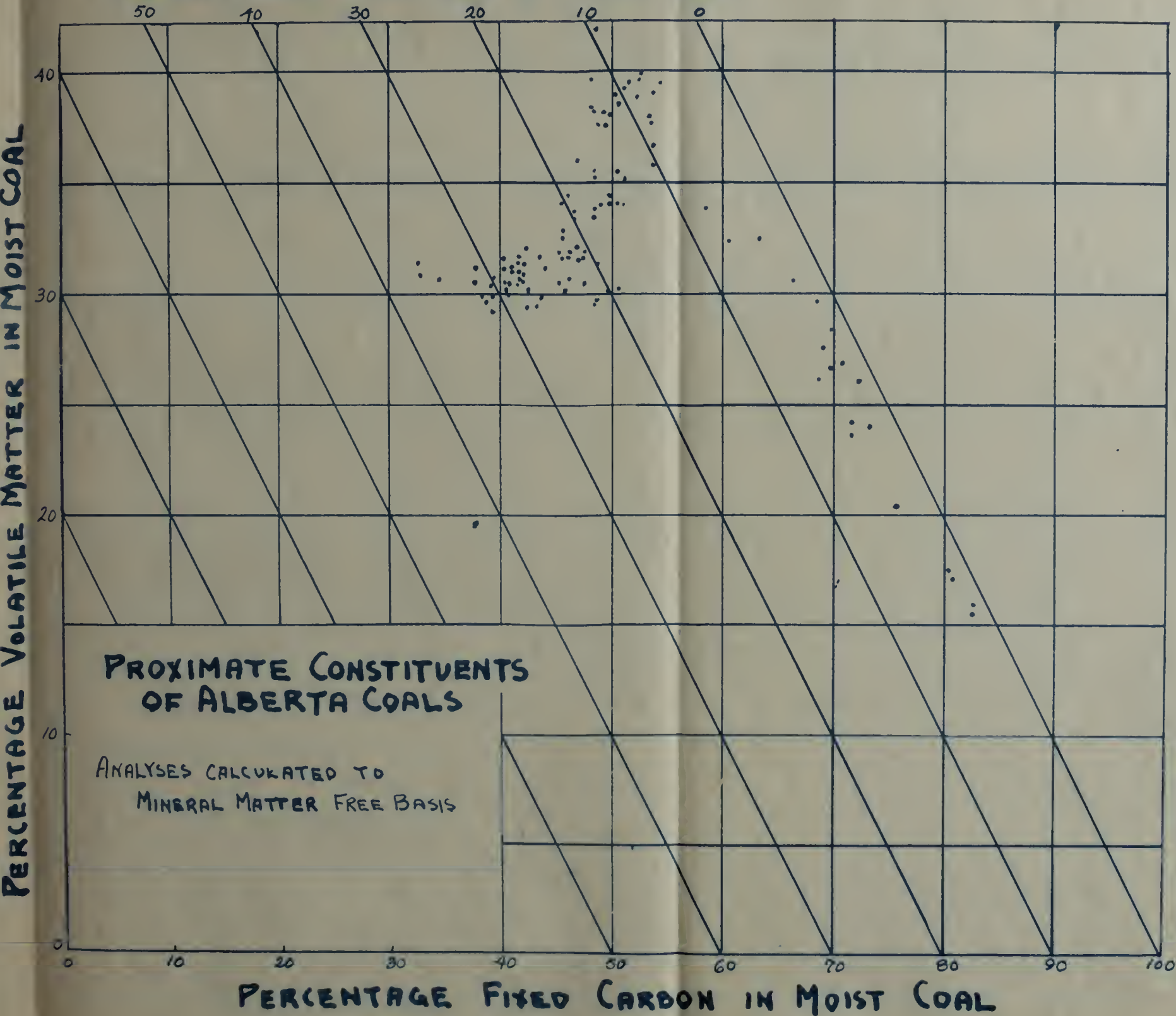
0

PROXIMATE CONSTITUENTS OF ALBERTA COALS

ANALYSES CALCULATED TO
MINERAL MATTER FREE BASIS

0 10 20 30 40 50 60 70 80 90 100

PERCENTAGE FIXED CARBON IN MOIST COAL



PERCENTAGE HYDROGEN IN MOIST COAL

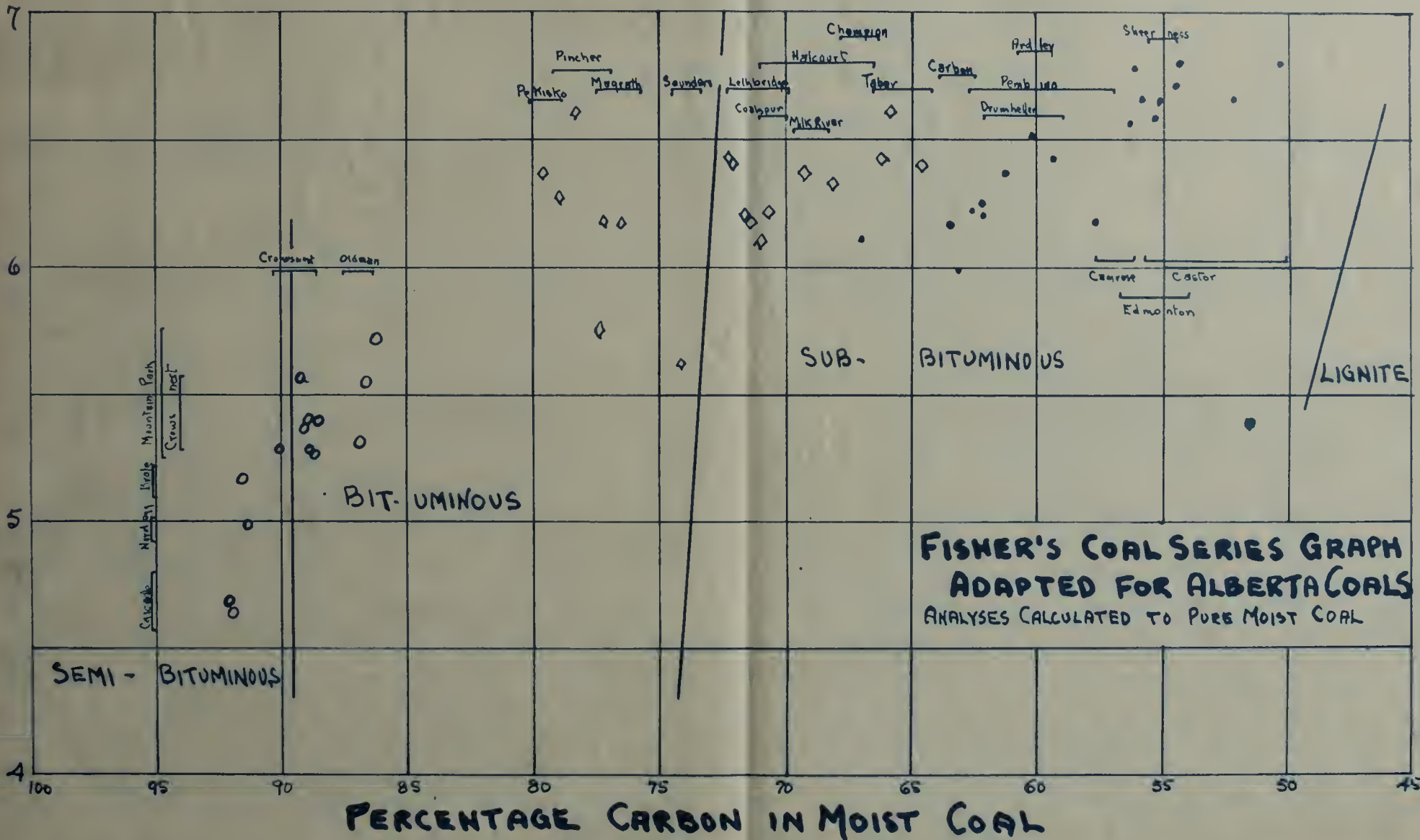


TABLE XIV. Dowling's Split Volatile Ratio - Applied to Alberta coals.

Title of Class	Anthracitic coal	High Carbon Bituminous	Bituminous	Low Carbon Bituminous	Lignite coal	Lignite
Definition of Class						
Fixed Carbon + $\frac{1}{2}$ V.M.						
Moisture + $\frac{1}{2}$ V.M.	10 - 13	6 - 10	3.5 - 6	3 - 3.5	2.5 - 3	1.0 - 2.5
Areas by Classes.						
Kootenay horizon	Cascade	Brule Nordegg Mountain Park (Inscar) Crowsnest (Greenhill) (Carbondale) (Tr. 7-0) Oldman	Mountain Park (2) Crowsnest (Dennison) (Bellevue) (Hillcrest) (Burmis) (Tr. 6-2) (Tr. 5-1)			
Belly River horizon				Pekisko (4) Pincner (2) Wegata (2-26)	Halcourt Coolspur Saunders Pekisko (18-2) Pincner (8-2)	Lethbridge Milk River Pekowki Taber Redcliff Brooks Sexsmith
Edmonton horizon						Pembina Edmonton Torfield Camrose Castor Ardley Big Valley Carbon Drumheller Gleichen Sheerness Champion

T A B L E X V. Carbon-Hydrogen Ratio - Applied to Alberta coals.

Title of Class	Semi-bituminous	Bituminous(1)	Bituminous(2)	Bituminous(3)	Bituminous(4)	Lignite	Peat
Definition of class							
Carbon/Hydrogen (Air dry coal)	23 - 20	20 - 17	17 - 14.4	14.4 - 12.5	12.5 - 11.2	11.2 - 9.3	9.3 -
Kootenay horizon	Canmore (Corev seam)	Canmore (Stewart seam) Nordegg Brule Mountain Pk. (1)(Luscar) Oldman (Skeen) Crowsnest (Dennison) (Hillcrest)	Mountain Pk.(2) Crowsnest (Bellevue) (Greenhill) (Carbondale)				
Belly River horizon				Magrath Pekisko Saunders Coalspur Pincher	Helcourt Letabridge Milk River (15 2)	Taber (3)	
Edmonton horizon					Pembina (53-7) Camunion (10-23) Drumheller #1 seam (28-19) #5 seam (29-20) Caroon	Pembina (53-4) 4 Edmonton(3) Camrose (46-20) Ardley (1) Drumheller #1 seam (29-20) (27-28)	Edmonton (55-24) Sneerness (29-14) Castor (3)

TABLE X V I. Distribution by Areas of the Classes of Coals Arranged by
Grout's Classification.

Title of Class	Semi-Antaracite	Semi-Bituminous	High Grade Bituminous	Low Grade Bituminous	Black Lignite
Definition of class	Fixed Carbon 83 - 93%	Fixed Carbon 73-83%	Fixed Carbon 48 - 73% C. 82-88%	Fixed Carbon 48 - 73% C. 76.2-82%	Fixed Carbon 35 - 60% C. 73.6 - 76.2%
Footenay horizon	Cascade	Nordegg Brule Mountain Park (2) Crowsnest (1) Oldman	Mountain Pk (2) Crowsnest (1)		
Belly River horizon			Pincner Mcgrath	Lethbridge Coalspur Milk River Tiber	
Edmonton horizon				Caroon Drumheller Pembina Edmonton Camrose	Torfield

TABLE XVII. Parr's First Classification - Applied to Alberta Coals

Title of Class	Semi-Antracite	Semi-Bituminous	Bituminous A	Bituminous B	Bituminous C	Bituminous D	Black Lignite	Brown Lignite
Definition of class:								
V.C. x 100	4 - 8	10 - 15 4	20 - 32	20 - 27	32 - 44	27 - 44	27 up	27 up
Carbon								
Inert Volatile			5 - 10	10 - 15	5 - 10	10 - 15	16-20	20-30
Areas of Classes:								
Kootenay horizon	Cascade	Nordegg *Brule Crowsnest (Greenhill) (Carbondale) (Dennison) (Bellevue) Oldman Mountain Park (2)	Mountain Pk. (Mountain Pk.) Crowsnest (Hillcrest)					
Belly River horizon						Pincner Pekisko Saunders Magrath Lethbridge (2)	Lethbridge (3) Carlsbur Milk River Tiber	
Edmonton horizon							Pemoline (53-7) Camrose (40-20) Caroon D'neller #1 seam (28-19) #5 seam (29-20)	Pemoline (53-4) Edmonton Castor Ardley D'neller #1 seam (29-20 & 27-18) Sheerness Champion

DISCUSSION OF FIGURES AND TABLES.

Seyler's classification, shown graphically in Figure 4, and summarized in Table X, was prepared from a study of the anthracitic and bituminous coals. According to this classification coals of the Kootenay horizon are placed in four classes or groups. The properties of these coals are well described by the descriptions for each group as contained in Table 1. Thus, Conmore coal from the Carey seam (ortho-carbonaceous, Welsh, smokeless steam, slight caking) does not show any indication of agglomerating in the platinum crucible during the volatile matter determination. Slight agglomeration is shown by the coal from the Stewart seam and the caking power of the coal increases through the ortho-semi-bituminous (steam coals, higher hydrogen blended for coke) group with increase in hydrogen. The meta-bituminous group is described by Seyler as containing the Welsh coking coals. Crowsnest and Cadomin coals occur in this group, the coals of which contain 20 to 23% volatile matter or slightly more, as mined when adjusted to about 10% ash. The ortho-bituminous group is said to contain the Durnam coking and gas coals. Mountain Park Colliery supplies the only coal among the Alberta coals analysed that falls in this group, and it answers the description well.

Only one coal, of which an analysis is available, falls in the para-bituminous class. This one comes at the extreme lower limit of the per-para-bituminous group. In work done on the hydrogenation of coal at the University of Birmingham, it was found that coals of the para-bituminous class were most amenable to hydrogenation.

Seyler's classification has been quite generally adopted by scientific workers for the coals of bituminous and higher ranks.

Coals below 84% carbon are subdivided mainly on the carbon content.

These are higher moisture coals and no account is taken of their moisture content. However, a fair range of values is obtained for the lignitous groups and lignite.

Seyler defends a classification based on the ultimate analysis on the grounds that "it gives the amount of the products of combustion, and the amount of oxygen required for complete combustion, - factors of great importance in the control of the efficiency of firing. If the coal is to be gasified in any form of producer it gives the amount and nature of the materials available for this purpose, or if it is to be carbonized, (especially in conjunction with the yield of coke) the elements available for the production of coke, gas, and by-products".

Classifications based on Volatile Matter and Calorific Value.

Parr's second scheme of classification, shown graphically in Fig. V and summarized in Table XI, being based on the pure coal, does not take into account the moisture of the water-holding properties of the coal. In the higher ranks a quite satisfactory division of the coals is obtained, but the same cannot be said of the division obtained for the lower ranks. In the alternative division into lignite and sub-bituminous classes, coals from Saunders and Brooks are thrown close together, as also are coals from Pembina and Tofield. The range of values in sub-bituminous and lignite is much too small.

Thom's classification (Fig. VI and Table XII) being based on the air dry coal, will not give the same division into classes in all laboratories, owing to there being no generally adopted standard method of air drying coal.

The arrangement of the low moisture, higher rank coals is much the same as that given by Parr's second classification. The lines of division, however, do not separate the Cascade coals from that of Cadomin and most of

those of the Crowsnest area.

The line of division between sub-bituminous and lignite, is not a satisfactory one, though a better arrangement is given than by Parr's classification on the pure coal basis.

E. Standfield's classification (Fig. VII and Table XIII) makes a satisfactory division between the higher rank coals, and in the lower ranks places the coals in very nearly the order of their relative values as domestic fuel. This classification being based on the moist coal, more nearly represents the coal as it is used, than do the two previously considered classifications.

An objection to classifications based on the calorific value and volatile matter has been based on the assumption that the calorific value of a coal is the algebraic sum of the heat of combustion of the carbon and hydrogen and the heat of decomposition of the coal. The latter is a negative quantity which increases with increase in oxygen content. Contrary to the above argument, it would seem that, if this be so, a classification based on calorific value, by including this factor, better represents the true value of the coal than can a classification based on the ultimate analysis.

Figure VIII shows the gross volatile as well as the calorific value of the pure moist coal, and spreads the points for coals over a larger area. No use for classification purposes has been made of this figure, since no change would be made except in the higher ranks in the value of volatile matter separating short and long flame bituminous. It was considered that sufficient use had been made of moisture content when the calorific value of the moist coal was used.

Fisher's Scheme.

The triaxial representation of the proximate analysis according to

Fisher's scheme (Fig. IX), shows the relative importance of dehydration and devolatilization at different stages of the formation of coal. Alberta coals do not follow quite the same line, nor do they fall in as narrow a ribbon as that shown by Fisher.

Figure X shows graphically the constituents considered to make up the pure coal. (The lines representing oxygen are not drawn, but the percentage of oxygen may be obtained from the relation, oxygen equals $100 - (\text{carbon} + \text{hydrogen})$). In the higher ranks where the moisture content is very low, a small difference in moisture makes a large difference in carbon, so that Luscar is shown as a bituminous coal, while Greenhill, due to a very low moisture content, is shown as a semi-bituminous coal. For the lower part of the bituminous rank and in the sub-bituminous and lignite ranks, the lines of division do not properly mark out the ranks. Thus Saunders is considered a bituminous coal, and Sneerness and Castor are placed in the sub-bituminous group. Tables VII, VIII and IX show some values of carbon in the moist mineral matter-free coal, and these serve as well as Fisher's graphical scheme. From those tables it is seen that the percentage of carbon in the moist coal decreases with decreasing calorific value. Limits might be imposed to base a classification for the lower rank coal on this value alone. Thus the coals which are classified by E. Stensfield's classification, as sub-bituminous, would be separated from those classified as black lignite at a carbon percentage of 70, while 54% carbon gives much the same division between black lignite and brown lignite as does the above mentioned classification.

Split Volatile Ratio.

Table XIV shows the division into classes by areas according to Dowling's split volatile ratio. This ratio being based on the air dry coal

is subject to the same objection as are other classifications on that basis. Table VI shows that much the same division of the higher rank coals is given by this ratio as by other ratios. For the ranks below bituminous, the range of values is small. A source of error in this ratio occurs owing to the fact that some coals have their volatile matter determined by the quick coking method, while others have this value determined by the slow coking method. The present lack of a generally accepted standardized method of air drying rules out this classification, since all laboratories would not show the same division into classes.

Carbon - Hydrogen Ratio.

The division into classes by Campbell's carbon hydrogen ratio is shown in Table XV. This ratio gives a fairly satisfactory range of values in the higher rank coals, but the value 18 would be better than 20, as given by Campbell, for the division between semi-bituminous and bituminous as already mentioned. Strechen and Pollard used this ratio in showing progressive anthracitization in the Welsh coal fields. It is quite generally agreed that the usefulness of this ratio does not extend below the bituminous rank. In bituminous and lower rank coals the hydrogen percentage does not vary greatly, but a small variation is quite a large percentage variation, and, with the much larger percentage of carbon, causes a larger variation in the ratio than is justifiable. Campbell uses the ratio on the air dry coal, but Tables VI, VII, and VIII show the ratio on the moist coal with no better result. The fact that coals from the Edmonton, Sheerness, and Oyster creeks fall into the class of peat definitely rules out this classification as being suitable for Alberta coals, excepting for the higher rank coals which fall into practically the same order by all criteria except calorific value, which is unsuitable for those coals, due to the small variation as shown in Figures V and VII.

Grout's Classification.

Insufficient data was available to plot many points by Grout's scheme, the arrangement given by which is shown in Table XVI. The division by fixed carbon in the higher ranks is the same as that by fuel ratio, while in the lower ranks the arrangement on the total carbon of the pure coal is that shown by Seyler's classification in Figure IV, and already considered. The limits as placed by Grout do not suit Alberta coals, since the class known as low grade bituminous places coals from Lethbridge and Coalspur in the same class as Camrose coals. Also the semi-bituminous class includes Brule and Nordegg as well as Cadomin and some Crowsnest coals, while Camrose is classed as semi-anthracite.

Parr's First Classification.

Table XVII shows the arrangement provided by Parr's $\frac{V.C. \times 100}{\text{Carbon}}$ ratio and by percentage of inert volatile. Insufficient data was available to properly test this classification. The ratio itself does not seem to be founded on any logical basis, since there is little connection between fixed carbon and either volatile or total carbon. The percentage of inert volatile requires the percentage of available hydrogen, which is a rather hypothetical quantity. In spite of objections to the theory of the classification it would seem to be capable of giving a satisfactory division into classes.

Miscellaneous Classifications and Data.

Table VI shows that the fuel ratio gives a satisfactory separation in the higher ranks of coals. A value of about 3.1 might serve as the point at which to separate the higher rank coals of Alberta into two classes. Table VII shows the narrow range of values of fuel ratio in the ranks below bituminous. The fact of Macereth coal being placed below some Pokowki coals is sufficient to condemn this ratio for these coals.

The percentage of oxygen is not capable of sufficiently accurate calculation to be made the basis of any classification. This fact has already been discussed at considerable length.

Table VI shows that there is insufficient range in the calorific value of the higher rank coals to use that as the basis of a classification for those ranks.

The classification of the twelfth International Congress gives several criteria for each class of coal. A few examples of the application of these criteria to Alberta coals should be sufficient to test its suitability.

Canmore coal yields from 14.5 to 17% volatile matter which places it in class B 1 or B 2. The fuel ratio is about 5.2 which places it in class B 1, the percentage of carbon is about 91 or 92 and this places it in class A 2.

Coal from Mountain Park mine yields from 30 to 34% volatile matter which places it in class C or B 3. It has a fuel ratio of 2.1 which places it in class B 2, the percentage of carbon is about 86, and on this account it belongs in class B 1 or B 2.

Coal from the Galt mine in Lethbridge has a fuel ratio of about 1.3; this places it in class B 2. The split volatile ratio is 2.4 which places it in class D 1. The calorific value is about 12,300 which would place it in class B 3, C, or D1. The percentage of carbon is about 72, which places it in class B 1.

The fact that different criteria place the same coal in different classes is sufficient to show the unsuitability of this classification for Alberta coals.

Ashley's first classification proposes the ratio fixed carbon as a
moisture

criterion for distinguishing between low rank coals. The ratio is shown by Tables VIII and IX to be capable of giving the same division into classes as that given by calorific value of the moist coal. The limits are unsuitable, as only the last three coals in Table VIII would be classed as lignites.

Ashley's second classification, based on the percentage of fixed carbon in the moist coal has an error owing to the use of results from the slow and quick coking methods of determining volatile matter. The classification is similar to that by fuel ratio of the higher rank coals. For the ranks below bituminous it is not so suitable. Tables VIII and IX show the values and the order of arrangement by this system. It will be noted that coals from the Helcourt, Coalsgur, Lethbridge, Magrath, Milk River, Caroon and Champion areas have a fixed carbon percentage of about 50. No one with any knowledge of these coals would group them into the same class. A variation in calorific value from 13,390 B.T.U. to 11,250 B.T.U. is shown by these coals, while moisture content varies from 7.3% to 17.1%.

Mr. Stensfield has done considerable work on the plotting of ratios and data on a map of Alberta showing the townships. He found that lines joining townships having the same moisture took a position roughly parallel to the Rocky Mountains, the moisture increasing with distance from the mountains. A similar map for calorific value of the moist coal shows similar lines with the calorific value decreasing with distance from the mountains.

The first column of tables VII and VIII show distances and relative distances of the townships, in which coal is produced, from the divide of the Rocky Mountains. These figures show some exceptions which are also shown in the figures (37) referred to above. Thus Pembina coal is mined at about the

same distance from the mountains as is Pakowki. The latter is a much lower rank coal. Champion and Lethbridge are about the same distance from the divide, but Lethbridge coal has been metamorphosed to a greater extent than has Champion. The coal of the Edmonton area is mined much farther from the divide than are some of about equal rank from Taber and Sheerness areas. Presumably pressure has not been exactly proportional to distance from the mountains. The development of faults in the geological structure at some place between the mountains and the coal area may have operated to lessen the pressure on the coal, and hence the maturing process may have been retarded.

Other values have been plotted in the same manner as was done by Mr. Stensfield. The calorific value of the pure coal did not show any regularity even in the same area. The percentage of carbon in the moist coal showed much the same regularity as was shown by moisture and calorific value of the moist coal.

Ignition temperatures for coals of the Kootenay horizon are shown in Table VI. It would seem that an ignition temperature of about 220°C might be used to divide those coals into two groups.

The following table shows ignition temperatures, percentages of oxygen in the pure coal, and the grams oxygen absorbed per kilogram of coal in the ulmin content determination.

Area and Township	Percentage of Oxygen in pure coal	Ignition Temperature	Grams Oxygen absorbed per kg. pure coal
Pincher (7-2)	8.6	184.0°C	12.9
Lethbridge (9-21)	12.1	178.0°C	25.6
" (10-21)	14.2	170.8°C	25.7
Milk River (2-15)	13.2	175.8°C	28.5
Taber (9-16)	14.8	172.3°C	38.3
Drumheller #1 seam(29-20)	16.7	165.2°C	32.7
Caroon (31-24)	16.2	165.8°C	36.6
Pembina (53-7)	15.4	166.8°C	42.5
Drumheller #1 seam(26-19)	17.1	161.9°C	88.7
" " (27-18)	17.7	160.5°C	46.8
Camrose (46-20)	17.7	157.6°C	54.6
Drumheller #5 seam(29-20)	16.3	157.5°C	42.6

An ignition temperature of 170°C would divide these coals into two groups. Insufficient determinations have been made to give enough data to draw any conclusions. S. Zeavin discusses the ulmin content in his thesis and it will not be discussed here.

A more satisfactory classification would be one in which physical and chemical properties are both made use of. The evaluation of physical characteristics of the coal, both as it is taken from the mine and also after storage would be of value in classifying the lower rank coals. Some work on the storage of coal has been carried out by the Scientific and Industrial Research Council, but insufficient data is yet available to be any use in a classification.

Conclusion.

The writer has attempted to discuss the merits of the different classifications which have been proposed. From the study of Alberta coals from the chemical standpoint, he is satisfied that the best classification of coals of bituminous and higher ranks, that is for coals of the Kootenay horizon, is provided by the percentage of volatile matter and by Seyler's scheme. For the coals of rank below those, that is for those of the Belly River and Edmonton horizons, the calorific value of the moist coal best distinguishes between these coals. Possibly the percentage of carbon in the moist coal classifies these coals equally well, but insufficient ultimate analyses are available to properly test out this factor.

Some of the ratios considered may give the same division into classes, but most of them are founded wholly or in part on data from arbitrarily standardized determinations. On the other hand, the criteria just mentioned, with the exception of the volatile matter determination for higher rank coals where the possibility of error is small, have an advantage in that they are definite quantities or values capable of very accurate determination.

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